



**The Economics of Electricity Market Reforms in Developing  
Countries: An African Experience and Lessons**

**By**

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**Title page**

**The Economics of Electricity Market Reforms in Developing Countries: An African Experience and Lessons**

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## Abstract

The restructuring of state-owned utilities in the power sector has been an ongoing trend for over three decades, with many countries adopting market-oriented reforms. One of the main expectations why developing countries embarked on power sector reform was based on the assumption that reforms would improve efficiency and enhance productivity levels within the industry.

This study seeks to verify the impact of market-oriented reform in the power sector, with a specific focus on the African experience. The project uses data on 30 selected African countries from the World Bank Development Indicators, the African Development Bank, the U.S. Energy Information Administration (EIA), the International Energy Agency (IEA), the Africa Infrastructure Country Diagnostic Database (AICD), and the Private Participation Infrastructure database (PPI), to construct datasets enabling us to complete panel, cross-sectional data and cross-country analyses for electricity reform spanning the period from 1989 to 2014.

In Africa, almost without exception, governments have amended their electricity acts in order to allow for greater private sector participation. In many cases the motivation to adopt market-oriented reforms have been strengthened by World Bank and other financial donors' recommendations to do so. Historically, Independent Power Producers (IPP's) were introduced as private electricity generators, to increase power generation. The IPPs normally signed purchase agreements with the state-owned utilities to buy electricity as a single buyer. The most common form of IPPs in the region are Build-Own-Operate-Transfer (BOOT) and Build-Operate-Transfer (BOT) enterprises. Multinational corporations such as *Electricite de France* (Edf), *US-based AES Corporation* and Germany's *Siemens* have played a dominant role in many countries in the region.

The *first empirical chapter* finds that each individual reform variable (on its own) is not sufficient to improve power generation performance. Instead, reform tends to be more effective when they are combined. So, for countries to obtain first-best outcomes in terms of electricity market reform, it is important to introduce more than one reform at a time in the reform process.

The *second empirical chapter* measures the electricity distribution efficiency trends of 231 electricity distribution companies in 16 African countries over a period of fourteen years

(2000 -2013). The analysis is based on a stochastic distance function approach, assuming that the number of outages (a quality of service proxy) enters into the company's production function as an underdesirable input, i.e. an imperfect substitute for (the lack of) maintenance activities and capital investment. This enables identification of the sources of technical inefficiency and the underlying trade-off between quality of service and other inputs/costs faced by the operators. Using a multiple output translog input distance technology, we found that exogenous factors affect estimated technical efficiency levels significantly. Our result also shows that incorporating quality of service is important in helping to benchmark performance of the different electricity distribution companies.

The *third empirical chapter* explores the notion that institution structures stimulate private sector investment. We used cross-sectional data for twenty-eight African countries between 1990 and 2014 to test empirically the impact of political institutions, market-oriented reforms and macroeconomic stability on private sector investment in the electricity market. The results generated from our models indicate that political institutions matter, but market-oriented reform and macroeconomic stability are insignificant. We also found private sector investment is greatly influenced by an increase in the real GDP per capita of a country. Somewhat surprisingly, our results suggest that African countries with a high corruption perception index attract more private sector investment in their electricity market.

Power sector reform in African countries is characterized by amending the electricity law (so as to attract IPPs), the corporatization of service provision, and the creation of new institutions (such as regulatory authorities) to support reform activities. There is currently no strong commitment to fully embark on privatization and unbundling across the region, as governments prefer to engage in public-private partnership. This system promotes a hybrid structure where state-owned vertically integrated power companies still dominate, acting as a single buyer. Governments and policy makers in this region should therefore adopt reforms that acknowledge local conditions, deepening their involvement in market-oriented reforms where necessary, in order to achieve first-best outcomes.

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## Declaration

Whilst registered as a candidate for the above degree, I have not been registered for any other research award. The results and conclusions embodied in this thesis are the work of myself, the named candidate, and have not been submitted for any other academic award

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## **Dedication**

I dedicate this piece of work to my late son (*Ifeanyichukwu Nworie Junior*), who died shortly after birth at Princess Anne Hospital, Southampton on 16<sup>th</sup> March, 2015. This is my special tribute to your struggle to live, but it was not to be. You have a special place in my heart.

**Rest in peace.**

# Chapter 1

## Introduction

The innovation of the incandescent light bulb by Thomas Edison in 1879 has transformed our way of life. Electricity is an essential source of energy; has helped consumers to satisfy human wants, in powering various machines that help, either directly or indirectly to produce consumer goods. We are not aware of any situation where electricity is directly consumed by human beings to satisfy their wants. Consequently, the demand for electricity always has to be a derived demand, derived from the goods and services, which are directly consumed by human beings and produced with its help.

Electricity is an essential commodity because its generation and consumption have to be concurrent and it cannot be economically stored. Another characteristic of electricity is that its demand differs in terms of hourly, daily, weekly, monthly and yearly basis. Thus as it is a non-durable good, ways to improve its quality of services becomes necessary.

### 1.1 Background and Motivation of study

Thirty years have passed since the first electricity market reform was introduced and there is now a need for critical/detailed evaluation and analysis of its economic importance and performance, especially in developing countries. It is therefore pertinent to examine the challenges, and the evidence in support and against the logic of the market-oriented reform in the electricity market as mentioned by various scholars [Bacon et al. (2002), Besant-Jones (2006), Eberhard and Gratwick (2005 & 2013), Eberhard et al. (2008), Jamasb and Pollitt (2005), Pollitt (2008, 2009a,b,); Zhang et.al (2008), Kirkpatrick et al. (2006), Felder et al.(2007), Sioshansi (2006a, 2006b, & 2008); Joskow (2006, 2008); and Kesides (2012)]. The existing differences in electricity supply industry models reflect differing views on the effectiveness of market-oriented reform in the power sector. In reality, the marginal benefit of each reform/restructuring must more than compensate for the marginal cost of such reform if it is to be considered effective or successful.

In the last three decades, we have witnessed an increase in the number of countries adopting different power sector reforms (such as regulation, privatisation, access of independent power producers to the generation sector and unbundling). Starting from the largest (such as China), to the smallest (in the case of Bolivia), many have significantly adopted a type of electricity

reform that suits their own needs, conditions and circumstances. Some involve privatization, third party access to transmission networks, independent power producers' access to the generation sector, unbundling and the creation of a regulatory body. These market-oriented reforms are expected to lead to increase in terms of quality of service, efficiency and productivity, and also improve access and lower the price of electricity.

Chile began a programme of restructuring and privatising her power sector in the early 1980s. It is regarded as the pioneer in adopting a market-oriented reform in its power sector, and more than half of the countries of the world have followed Chile in reforming their power sector. To some countries it is impossible (or undesirable) to embark on any type of electricity reform programme that encourages the opening up of their electricity production/generation, transmission and distribution or sales to private investors, whereas in other countries it is viewed as a welcome way to involve the private sector in the electricity supply industry. Thus, replacing government involvement in public enterprises with private enterprises in network utilities industries is on the rise in both the developed and developing countries.

Nevertheless, the network utilities industry has proved to be a challenging area for the introduction of market-oriented reform as the industries are characterised by high capital investment and require long maturity periods in order to earn an acceptable return on investment. Moreover, service providers (such as telecommunications, electricity and water) that provide essential commodities are often highly visible politically, which increases the risk of likely government intervention if market activities become politically inconvenient (Victor & Heller. 2008).

The primary economic arguments in favour of state intervention in the electricity market related to the nature of the industry. In the electricity sector, economies of scale and scope are important (i.e. horizontal integration leads to cost savings, especially with hydro and coal-based power plants, and closer coordination reduces wastage).

The need for embarking on electricity market reform arose from two key factors: firstly, dissatisfaction over the poor technical, financial and managerial performance of the state-owned electricity corporations. Secondly, the inability of the government to finance state-owned utilities properly. Thus a lack of investment inflow to the system, led to irregular maintenance in the power sector, especially among developing countries. So it has been difficult to replace public sector enterprises with private enterprises. Nevertheless, despite



these obstacles, there are some network industries that have successfully introduced market-oriented reform (such as telecommunications).

Scholars such as Joskow; (1997, 1998, 2000, 2001, 2006, 2008), Bacon and Besant-Jones (2002); Victor and Heller (2004); Babatunde (2011); Sioshansi (2006a, b); Jamasb, Newbery and Pollitt (2007); and Eberhard (2008) have identified: (i) The poor performance of the state-owned electricity industries in terms of high costs, wastage, corruption, inadequate expansion of access of electricity services to the large population, unreliable supply; (ii) The inability of the state-owned utility company to finance its own maintenance costs and expansion activities. Thus in general the motivation of reform in the power sector is to improve the efficiency of the sector, to offer lower price-cost margins and to offer a better quality of service.

Power sector reform in developed and developing countries is fundamentally different in terms of sector conditions and institutional framework. In developed economies, the main reason for reform is to improve the efficiency of the sector, by encouraging inter-regional (cross-border) trade, sharing investment risks with the private sector and offering customers' choice on their suppliers. Meanwhile, for developing countries where policies of industrialisation were encouraged, these have left the power sector with short-term excess capacity, so that new capacity was a lower priority than in most developed countries. So the main motivation for reform includes; (i) the poor performance of state-owned vertically integrated electricity companies (in terms of high costs, inadequate maintenance routes, low expansion of access to electricity service and unreliable power supply). (ii) Insufficient funds to meet the investment needs of the corporations, (iii) the need to remove subsidies in the electricity supply industry and channel the resources to other pressing public needs. (iv) The need for the sector to be competitive and contribute to growth of the economy: and lastly (v) the desire to raise revenue for the government through the sale of assets from the sector (Zhang et al. (2008) and Besant-Jones (2006)).

Based on the expectation that market-oriented reform in the power sector will lead to higher access to electricity connectivity, labour productivity and better use capacity utilisation, developing countries embarked on electricity market reform. However, when applying theoretical insights into aspects of economic performance in the power sector, there are specific features of the sector that need to be considered. The power sector is characterised by large sunk cost, minimum economic scale and non-storable and massively consumed outputs.

These factors provide governments with the possibility of behaving opportunistically *vis-à-vis* the investing companies. Knowing that, under some circumstances, governments may not be able to refrain from renegeing on explicit or implicit agreements, private investors may therefore be cautious about investing in power utilities. As a result, the actual effect of liberalization policies on power sector performance and growth is not unambiguously clear.

Against this background, this study aims to provide answer to the following questions:

- i). Does liberalizing the electricity power generation sector in Africa promote efficiency, increase productivity and higher capacity utilisation?
- ii). Do power system size, and market-oriented reforms improve the efficiency level of electricity distribution companies in Africa?
- iii) Lastly, do political institutions, liberalization policies and macroeconomic stability matter in attracting private sector investment into the electricity market in the African economies?

Electricity market reforms are often referred to as *electricity liberalization*<sup>1</sup>, *restructuring*<sup>2</sup> and *deregulation*<sup>3</sup>. The most common types of electricity market reform are:

*Electricity law amendment*: reviewing electricity acts to establish a sound legal basis for power sector reforms.

*Corporatization (sometimes refers to as commercialization)*: is the act of converting (a government-controlled industry or enterprise) into a limited liability corporate body often with the government as the main shareholder (*This type is common among developing countries*).

*Management contracts*: Can be described as a situation where the management of a utility is contracted out to a private entity to manage for a specific period of time. The contract is subject to renewal or termination by both parties.

*Independent power producers (IPPs)*: Constitute a key type of electricity market reform. With demand for electricity outstripping supply among developing countries, allowing

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<sup>1</sup> Electricity liberalization means the removal of restrictions on entry and exit into the electricity supply industry, making it open to any prospective and interested players (firms) to enter. Sometimes it implies reduced state intervention.

<sup>2</sup> Restructuring in electricity utilities is the same as unbundling – which is the process of breaking-up a vertically integrated state-owned utility into either different entities or companies.

<sup>3</sup> Deregulation – Can be described simply as the drastic reduction of the government's participation in the electricity sector by opening up the sector to the private investors.

independent power producers (IPPs) access to electricity generation is expected to enhance power generation capacity in developing countries.

*Privatization*: refers to the involvement of private sector investment in utility companies. This involvement can be partial ownership or the full sale of the utility by the government to a private owner.

All these types of market reform in the electricity power industry aim to dismantle vertically integrated utilities into separate components/segments, creating competitive markets at both the wholesale and retail levels, and require changes in a country's legal, regulatory and financial systems in order to enable such reform to work effectively.

Although there are a number of studies that have examined the impact of electricity market reforms on electricity performance indicators, the majority of these studies focus on the experience of the developed countries [*See – Ehrlich et al. (1994), Pollitt (1995), Martin and Parker (1997), Ros (1999), Villalonga (2000), Saal and Parker (2000, 2001), Joskow (1997 a, b, 2000, 2001, 2005, 2006 a, b, and 2008)*]. While some studies have focused on the developing countries [including; Baer (1994), Spiller and Martorell (1996), Lalor and Carcia (1996); Chisari *et al.* (1999), De Oliveira (2003), Williams and Dubush (2004), Kirkpatrick *et al.* (2006), Pollitt (2004, 2006), Zhang *et.al* (2008), Erdogdu (2011, 2012); Nepal & Jamab (2013)], there remains a paucity of studies that use econometric approaches in analysing power sector reform. Among the few studies that provides insights into the impact of power sector restructuring on performance indicators in developing countries, is Zhang *et al.* (2008), and Erdogbu (2011, 2012 and 2013) which focuses on selected Asian, OECD, South Africa and Latin American countries.

Empirical evidence seems to suggest that assessing the results of electricity market reforms (i.e., the effects of privatisation, competition, unbundling and regulation) should not only be considered separately, but in some form of combined or interactive effect model. While most existing studies of electricity market reform have dealt with one or two of these reforms to the best of our knowledge, there are no studies that exclusively analyse electricity market reform activities in African countries using an econometric approach (1989 – 2014). This can be attributed to fact that reforms in most of the African region are still relatively recent, meaning that only now is enough data becoming available to permit econometric analysis. This gap in knowledge motivated this study. The rationale behind the selection of these countries were based on availability of data and the fact that there represent not only the

majority of the African continent's population (some 1 billion people), but they are also provide a representative spectrum of national and electricity sector characteristics.

## 1.2 Scope of study

This study intends to analyse the impacts of market – oriented (liberalisation) policies on power utility performance in developing economies with particular focus on the African region. By liberalisation we mean the use of market or semi-market mechanisms as part of a reform of the power sector.

By competition we refer to the mechanism of allowing different players to participate in the market on a level playing field. We assume this encourages efficiency and promotes quality service delivery and performance in the sector.

The approach we adopted in this study is an econometric one. According to Jamasb *et al.* (2004) they argue that an econometric approach is the best suited approach for analysing and testing of hypotheses in a study like this. They also maintain that this approach is the most suitable when analysing cross-country study since it involves in-depth investigation or qualitative analysis. Thus, this study will develop a cross-country analysis of the economics of electricity market reform in Africa. We will focus on estimating, identifying and designing a better framework to shed more light on the electricity market reform in African countries.

Finally, one constraint to this study is data gathering as it is difficult to gather detailed data on all aspects of sectorial reforms in power sector in the African region.

## 1.3 Sources of empirical data

This study covers a period of twenty-five years (1989 – 2014). The year 1989 is chosen because it was in this year that electricity market reform (EMR) was first initiated in the African region. The final year (2014) represents the year for which a reasonable quality of data on African countries is available. We intend to include almost all the African countries that have adopted (various kinds of) electricity market reform. Due to the fact that not all observed countries started reform in the same year, we will employ both balanced panel data and aggregated cross-sectional data.

We will depend on data obtained from the African Development Indicators, the African Development Bank database, the World Bank Development Indicators database, Private Participation Infrastructures (PPI) Database – World Bank, World Bank/Enterprise Database,

the US Energy Information Administration, the International Energy Agency (Non-OECD countries database), different country regulatory statistical bulletins, and reports from various international and national web sites and papers.

#### **1.4 Structure of the study**

To carry out this empirical analysis of electricity market reform in developing countries, we structure this thesis in the following way: Chapter one provides the introduction, the researcher's motivation for embarking on the research, the scope of the study, sources of empirical data and the structure of the study.

Chapter two focus on the literature review, which consists of a: theoretical foundation, an empirical foundation, the econometric modelling approach, the political economy approach, the rationale behind power sector reform. Chapter 3 provides in-depth insight to the experiences of market-oriented reform among both developed and developing countries and power sector reform in African countries.

We present three independent but inter-related empirical chapters which consists of chapter 4, 5 and 6. Each of the empirical chapters has its own specific literature review. We are mindful to discuss the specific literature of each of the questions that give rise to this research. This provides a link between the general theme of the research and the question/objective of the study.

Chapter 4 answers the first research question and objective (*to what extent do liberalisation policies impact on the power generation performance*), Chapter 5 examines the second question and objectives – Measuring technical efficiency in African countries electricity distribution utilities: A Stochastic Input Distance Function Approach. Chapter 6 investigated the third questions & objectives of study – examines the factors influencing PPPs- investment in the African electricity market. Chapter 7 deals with the conclusion, policy recommendation and suggestion for further studies.

#### **1.5 Contribution to the existing literature**

This study will benefit policy makers, energy regulators, country specific power utility companies, academics and others interested in power sector reforms. The empirical chapters have three features in common. First, they all focus on power sector reform and analyse a specific feature of it. Second, it is built on a cross-country approach; (i.e., we do not concentrate on a specific country later it was based on a particular region – Africa).

Third, our results do not just identify shortcomings or weakness, we also suggest the way forward in the form of policy recommendations (*see chapter 7*). Our results shown that the standard model in power sector reform involves gradual steps that move state-owned vertically-integrated utilities towards the market and is characterised by: corporatisation/commercialisation, amendment of electricity Law/Acts, establishment of an independent regulator, involvement of the private sector (in the form of IPPs, divestiture of generation and distribution assets, concession and Management contracts), unbundling and the introduction of competition. But is not sequentially followed by developing countries as country situations differ and what works for one will not automatically work for the other (Eberhard and Gratwick, 2011).

There are numerous works in this field, mostly empirical studies that have analysed electricity market reforms focused generally on a single/cross -country in OECD, Europe, North or Latin America, others concentrate on Asia, Pacific, Middle East, and a few Africa countries, although not as a whole. Pollitt (1997) examined the impact of liberalisation policy on electricity market performance in OECD countries, and suggested that market-oriented reform in the form of privatisation has impacted positively on some countries electricity sector, such as Great Britain, Norway, Sweden, Argentina, New Zealand and Chile. However, the study maintained that privatisation in these countries does not lead to lower costs in short run.

According to Nagayama (2009) the introduction of liberalisation policies in some selected Asian developing countries led to a decline in cross-subsidisation in the electricity market. Although in Latin America, the impact of liberalisation on energy prices were mixed. As liberalising the industry led to an increase in both wholesale and retail energy prices.

Other scholars (Joskow, 1998; Briceno-Garmendia et al. 2004) examined the impacts of market oriented reform on access to electricity and quality of service. They maintained that reforms were expected to enhance electricity generation, lead to efficient utilisation of installed capacities and increase new generation capacities by attracting private investment, and to reduce electricity outages. In addition, studies by Cubbin and Stern (2006), Zhang et al. (2008) and Erdogdu (2014) find that regulation, capacity utilization and competition have promoted service delivery, generation capacity expansion, capacity utilisation and reserve margins among some selected developing countries.

The essence of restructuring of the market structure in the electricity sector is aimed at improving the efficiency and productivity of the industry through introducing market competition (Jamash et al. 2017). Early studies of the Latin American countries electricity market showed an improvement in efficiency and productivity in the industry. However, there are few cross-country analyses of technical efficiency levels of African countries electricity markets.

On the other hand, one of the main aims of reform in the electricity market, especially among developing countries was to increase private investment in the electricity sector. Studies by Trebilcock and Rosenstock (2015) examined inefficient and costly energy delivery and documented how governments in developing countries have turned to public-private partnerships (PPPs) to fund electricity network expansion over the past two decades. Their findings shows that institutional capacity is among the key determinants of public-private partnership in electricity market.

There is a research gap in this area of study. Using panel data in all the three empirical chapters, this piece of work attempts to fill this gap in the literature;

The first empirical chapter examines the extent to which market-oriented policies impact on the performance of the electricity generation sector. Thus, market-oriented reforms in the form of Structural and institutional reforms are not the end but a means (i.e. there are necessary, but not sufficient conditions for improving the performance of power generation sector). Our result suggest that individual reform variables on their own is not sufficient to improve the performance of the power generation segment, rather they tend to be more effective when they co-exist or interact with other reform variables. So for countries to obtain first-best outcomes in electricity market reform, it is important to introduce more than one reform at a time in the reform process.

The second empirical chapter assesses technical efficiency of the regulated segment of the industry (electricity distribution). We carry out this study using stochastic frontier analysis (SFA). Sectorial reforms are not sufficient to raise the quality of service, improve the distribution network and reduce the cost levels, comparable to those of developed countries. However, as the IDB (1997) argued Latin America could increase its growth rate by between 1.2 and 1.7 percentage points as result of gains from structural reforms. Then, it is possible for African countries to also experience an improvement in electricity distribution. Our findings indicates that amount of energy delivered, number of customers and the number of

transformers has a significant influence on the technical efficiency levels of the electricity distribution companies. Similarly, we find that there is not much difference between the (mean) technical efficiency of countries with many distribution companies and/or those with one/few companies.

In the third empirical chapter, our findings shows that institutions matter. For market-oriented reform in power sector to yield good success and attract private sector investment it depends on the strength of the institution, this to attribute to the reason why African countries struggles. Our result indicates that strong institutional structure is the bedrock for a successful reform. The institutional variables do not individually contribute much in term of the proportion in variation in attracting private sector investment, but it matters. Furthermore, our findings shown the real GDP per capita is the sole determinant of private sector participation. Private sector investors consider the prosperity level of a country in their investment decision (i.e. they goes to countries that can afford their service, as return to investment is key).



## Chapter 2

### Literature Review

#### 2.1 Introduction

For over three decades the pace and the extent of the spread of market reform to nearly every aspect of modern economic activity have been remarkable. Network industry supplies essential services such as telecommunications, electricity, natural gas and running water.

*Reformers have sought to replace state control with private enterprise and market competition in air transportation, telecommunications, banking, ports, railroads, food service, and sundry other activities. Even Russian vodka, for decades a guiding spirit of the planned economy, is today a product of private entrepreneurs rather than solely state enterprise. (Victor and Heller: 2007).*

However, services supplied by network industries have proved to be a challenging area for the introduction of market competition because they require significant capital investment and the return on investment is slow, as it takes a longer time for the investment to mature. These services are also often subject to political intervention for, if left alone, they may deliver outcomes that are not in the interest of the government. Indeed, in some countries, these essential services are regarded as a central function of government, especially in those countries where the government is the largest employer of labour. It has also proved difficult to replace state corporations with private enterprises, because of the benefits of economies of scale which arise as a result of network interactions, and so these industries are prone to natural monopoly (Victor and Heller, 2007).

However, even if the government decides to open up network industries to private investors, they have to set up an institution to monitor the activities of the operators closely, to detect, sanction or punish any private firm(s) that seek to use their monopoly position to exploit the consumers – this requires establishing an independent regulator. Despite these challenges, the technological progress and the benefits of successful market reform in some countries has encouraged other countries to embark on infrastructure reform, for example, the auctioning to private enterprise of concessions to manage and operate toll roads, airports, and seaports. Also, in the telecommunications sub-sector, privatisation and technological innovations have eased the barriers to entry for new competitors in the industry creating a new product (such as wireless telephone, internet telephone, etc.) and rendering the old-guard (state-owned

enterprises) powerless. These new products provide competition, enhance the quality of service, promote efficiency and can reduce prices as well. All these benefits have helped to justify the advantages of, and the need for privatisation in, network industries.

Power sector reform is proving to be difficult for reformers however because of the nature of the industry; it is difficult to store electricity, and the network effects of large power grids encourage economies of scale in modern central power stations, which creates a barrier for new entry, making the sector the hallmark of a natural monopoly (See figure 2.1). Yet, despite these barriers (such as high capital costs, political factors, network monopoly effects, technological stasis and regulatory insight), private enterprises have found ways to introduce market forces into the business of electricity (Victor and Heller 2007). The idea of introducing market forces into the power sector started in the early 1980s, with Chile the first country to start the restructuring of their electricity industry, followed by Great Britain (under the Thatcher government) and then other countries. Their experiences have shown that some aspects of the electric power system are best left for the state-owned enterprises to operate, such as the transmission and distribution networks as they are prone to monopoly because of power poles and high tension lines. Although it is not impossible for these to be managed by private firms in the form of concessions or management contracts.

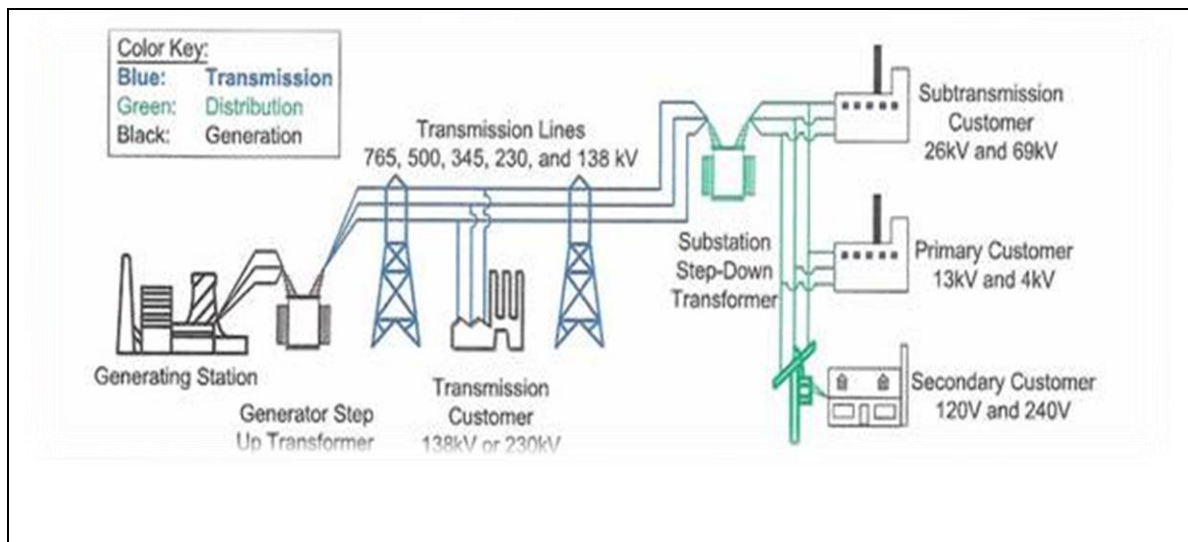


Figure 2.1: Electricity network of generation, transmission, distribution and supply

Great Britain under the Conservative government led by Mrs Margaret Thatcher was the first to apply this privatization idea on a large scale. They restructured the power sector in England and Wales, by unbundling the integrated state-owned enterprises into several competitive generators. They also established twelve regional distribution companies, each

with a specific franchise area of coverage, but maintained the transmission system as a single entity managed by the state-owned enterprise (now investor owned). Following the successful market reform of the power sector in Great Britain and other developed and developing countries, this encouraged other countries to the extent that, by the end of the 1990s, most of the OECD countries and over 70 developing countries had taken some steps toward reforming their power sector (Bacon, 1999; Steiner 2001). This trend was based on dissatisfaction with the performance of state-owned and controlled power sectors, and a desire to enhance the performance and the efficiency of the sector.

## **2.2 Why restructure, or change the status quo in the Electricity Market?**

Prior to the introduction of reform programmes or the restructuring of the electricity industry in many different countries of the world the power sector was generally structured and managed under one, or a combination, of the following: (i) as a government-owned enterprise (GOE) or (ii) as privately owned and regulated monopolies (as was the case in some US states and Japan).

Thus, in the case of government-owned enterprises, there was no independent regulator, except for a distinct part of the government (i.e. the Ministry of Energy & Power), in charge of the regulatory oversight of the industry. The shortcoming of this model is that the taxpayers bear the burden and risk of the activities of the industry, while there may also be a lack of accountability and proper management of finances since the government agency is not directly accountable to the consumer or stakeholders. Also, there is an issue of circularity, since different arms of the government tend to get involved either in the building, planning, forecasting, investing and the setting of tariffs over the operating of the power sector. This may lead to a lack of coordination, poor customer services and reduced technological innovation. In the case of emerging economies, governments may not have sufficient funds to invest in electricity infrastructure, thus resulting in chronic power shortages and poor service delivery.

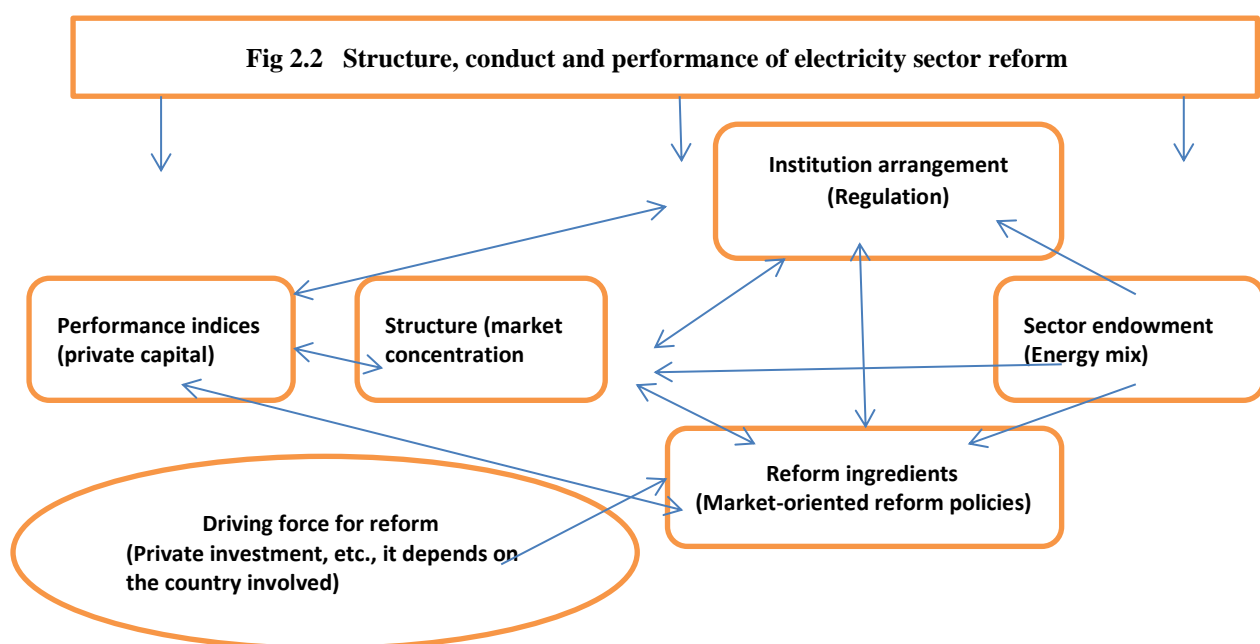
Moreover, there is some emerging evidence that, where power utility is privately owned or is a regulated monopoly under the supervision of an independent regulator, there tends to be higher productivity (Victor and Heller 2007). This model has some merits over the former when there is a competent, resourceful, independent and vigilant regulator as a watchdog. Some of the potential advantages are; there tends to be *stability in prices, adequate supply, high performance and efficiency in management* and it encourages *long-term planning*. Some

of the demerits of this model are; *Price disparities* – since different firms provide for different states or provinces. Again, there is the problem of *No customer choice* – the service provider gets exclusive areas, so the customers in such areas do not have an option of alternative providers. Also, there is the issue of the *transfer of risks to the ratepayers* as, typically, firms tend to transfer all their investment risk to their captive customers, who bear it in the long-run.

### 2.3 Framework for the study of electricity industry reforms

Market-oriented reform in the electricity supply industry is a multi – dimensional process, in that it differs from country to country. It is based on a set of specific objectives a country or jurisdiction sets out to achieve using a specific model. At one level, these reforms may be in the form of structural or organisational changes, at another, it may require establishing an autonomous/independent agency to regulate the activities of the industry.

In considering reform in the electricity power sector, the following need to be identified: the sector endowments, specific characteristics or features such as market size, generation energy mix, the historical background of the industry and its market structure. The process of reform can be monitored through performance indicators such as operating efficiency and the level of increase in investment in the sector. See figure 2.2 for an illustration of the inter-relationship between the various linkages in electricity sector reform.



**Figure 2.2:** Structure, conduct and performance of electricity sector reform  
Source: Jamasb et al. (2005)

## **2.4 What does theoretical evidence suggest on the electricity market reform?**

From a theoretical perspective, we assume that a reform should be only embarked upon if, and only if, it will improve the efficiency and quality of service of the power sector. This does not mean that governments necessarily conduct a social-cost-benefit analysis before embarking on a reform programme, but rather they tend to rely on less formal types of assessment (UNESCAP, 2001).

This sub-section focuses on the theoretical framework, with an emphasis on competition, regulation and private participation, on which the rest of the study will be built; it will answer the question of whether or not electricity is a natural monopoly by examining the theories of contestable markets, monopolistic bottlenecks and agent-based models.

Our theoretical foundation starts with the assumption that firms are willing to enter an industry or market if there are incentives to maximise profits. Thus, the following conditions must exist; there is no barrier to entry and exit, firms have the ability to set prices and an opportunity to invest in new technological innovations at an optimal level. But in reality, there exist some obstacles to markets not functioning the way there are designed to be. Such problems can be referred to as market failures (i.e. due to asymmetry of information, economies of scale through monopoly deadweight loss, and externalities). So regulation needs to be introduced for the market to function properly. The government intervenes by setting up regulations, but if the situation still does not work as expected, then there is a case for deregulation. Deregulation can come in the form of privatization, restructuring, corporatization/commercialization and unbundling. In our analysis, we focus on the power sector specifically. This sector is characterised by its natural monopoly nature in terms of its operation and needs specific regulation.

In principle, a suitable economic model necessary for establishing a regulatory framework for disciplining firms involved in any manipulation of their market power is essential in an open network industry such as the power industry.

### **2.4.1 Sector specific market power theories**

Economists argue that setting prices and determining the level of output does not solely depend on the type of industry or market. In other words, whether the market structure is in the form of a monopoly or perfectly competitive industry does not itself constitute a problem. The main problem is if there is a barrier to entry (for example if a single firm owns all the

strategic resources, sets prices and makes abnormal profits without fear of any form of competition). Such a firm may not, therefore, be as efficient as when there are other firms in the industry.

Thus, let us relax our assumption, and consider there is no barrier to entry, the firm does not own all the means of production in the industry, and there are other firms competing at the same level. This encourages greater competition and the price will be lower, thus making the industry more contestable.

#### **2.4.2 The theory of Contestable markets**

Baumol *et al* (1982) maintain that *a market is considered to be contestable if the entry is completely free and exit is completely free as well*, and where an entrant firm can displace any existing firm in the industry before that firm can respond (Shepherd 1984). They argued that such markets provide efficient results not only in principle but also in actuality. As with a perfectly competitive market, a contestable market is characterized by zero economic (break-even) profits in the long run. This theory is based on the condition that for potential competition to function properly there must be a perfect close substitute – under the assumption that there is:

*Free market entry* – there exist a large number of firms engaged in the same business in the market.

- *Sunk cost* – We mean those costs that cannot be easily recovered if a firm is shut down. The firm can only recover some percentage of the cost if there are firms willing to buy the business from the initial firm. Network utility industries are characterised by this type of cost.
- *Equal level access to innovation* – It is assumed that firms have an equal level of access to technological innovation.

Weitzman (1983), Schwartz and Reynolds (1983) and Schwartz (1986) criticized Baumol and his associates and argued that in a network/utility market, existing firms do have the advantage of greater market information, and a higher level of technology over the entrant. Therefore, the incumbent can enjoy high economies of scale in the form of lower average cost of production. In contrast, the new firm entering the market does not have sufficient knowledge and/or the right set of technologies to use and, as a result, will end up incurring a higher average cost of production.

However, it is true the simplified model of this theory does not equate to reality, but that does not mean that allowing competition in markets should be rejected. Indeed, this theory is regarded as the benchmark for the deregulation of public utilities. Although the influence of the contestable market theory in the academic world lasted for a decade, a new theory based on regulation reform gained support and became popular in the academic world in the 1990s.

### 2.4.3 Incentive Regulation theory

The incentive regulation theory is based on the idea that governments should establish an independent regulator to determine and regulate prices to some extent, as this will lead to economic improvement and better performance (Kridel., Sappington and Weisman 1996). This theory has been employed in telecommunication industries. In this theory, we can identify three kinds of incentive regulation;

- *Rate of Return regulation* – This is a type of regulation whereby the firm is allowed to make some profit (a fair *profit incentive*), but the firm also has to improve its efficiency and productivity levels. Mathematically: let  $\Pi$  represent profit gained,  $\Pi_\alpha$  stand for benchmark profit,  $\Pi_\beta$  represents the realized profit.

Thus  $\Pi = \Pi_\alpha + \beta (\Pi_\beta - \Pi_\alpha) = (1 - \beta) \Pi_\alpha + \beta \Pi_\beta$ . Where  $(1 - \beta) \Pi_\alpha$  stands for benchmark and  $\beta \Pi_\beta$  for actual profit.

- *Price cap regulation* – In this type of regulation, the government sets an average price the firm should charge. Mathematically; let  $P_t$  stand for a given price at period  $t$ , RPI is the rate of price index,  $X$  represents the rate of growth in productive efficiency, and  $Z$  is the adjustment rate of other factors.

Thus  $P_t = P_{t-1} (1 + \text{RPI} - X + Z)$ .

- *Yardstick regulation* –The third form of the regulation provides a form of competition, by comparing different regional (comparable) monopolies to each other. For example, the mean of the cost of a comparable group of firms can serve as a performance benchmark. Thus, we denote it with the below formula

$$P_{it} = \alpha_i C_{it} + (1 - \alpha_i) \sum_{j \neq i}^n (f_j C_{j,t})$$

Where:  $P_{it}$  is the overall price cap for firm  $I$ ,  $\alpha_i$  = share of firm's own cost information;  $C_{it}$  equals the unit cost of the firm,  $f_j$  stands for revenue (or quantity) weights for a group of

comparable firms (monopolies),  $C_{j,t}$  represents the unit cost (or prices) for the group of firms and finally  $n$  denotes the number of firms in the group (Shleifer, 1997).

#### 2.4.3.1 Risk sharing parameter among incentive mechanisms in the electricity market.

Let consider a static model with asymmetric information, suppose utility firm can reduce its cost and improve its efficiency by making increase its efforts<sup>4</sup>. To illustrate this, let the cost to the firm are affected by the effort ( $e$ ), such as the  $c = \varphi - e$ , where  $\varphi$  denote an unknown parameter to the utility regulator (i.e. low cost can be as a result of good luck or hard work). Therefore, let the cost of effort by the utility firm be in the form of convex function  $\alpha(e) > 0$ .

We shall focus on the regulation of utility firm which aimed to maximise profit. If the regulator set price  $\bar{P}$ , then the utility firm is free to choose any price such as  $p \leq \bar{P}$ . Moreover, if the regulator provides for the customers fraction of the profit  $\beta(p)$  made by the utility firm, where  $\beta'(p) > 0$ , such as the higher the fraction the higher the price charged by the firms. The firm's objective is to maximise profit  $\pi(1 - \beta(p))$ . Therefore, let  $\beta(p)$  be the range of  $0 \leq \beta \leq 1$  for  $p$ . The utility firm's incentives to increase its effort depend on the regulated price  $p$  as varies with cost ( $c$ ). Such as that  $\beta = dp/dc$ . Where  $\beta$  represents the cost or profit shared. Thus, if  $\alpha(e) = 1 - \beta$ , price-cap regulation has  $\beta = 0$ , and return to scale regulation has  $\beta = 1$ . Here the  $\alpha$  is the weight on the profits and it satisfies the condition that  $0 < \alpha \leq 1$ . Then the former has a better effort incentive, medium shared risk but with high risk than the latter. For the profit sharing regulation has medium risk shared and good incentive, while yardstick or benchmarking regulation has strongest incentives but with high risk sharing. Therefore, the regulator have to make a compensating adjustment in setting price.

Among the three-incentive regulation, the issue of cost recovery in rate of return regulation proved to be the source of concern. We illustrate with below example. If the regulator permits a rate of return which is higher than what the electricity distribution companies actually needs, in order to ensure the shareholders, have capital for investment. This could led for the distribution companies to increase their return by making unnecessary investment, which is assumed to be inefficient.

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<sup>4</sup> This efforts are assumed to be unobservable as the regulator could not distinguish.



Furthermore, as in the case of rate of return leads to inefficient performance, the regulator should adopt a better approach that is optimal. To do that, the regulator employs an efficient firm (benchmarking firm) with cost level  $\bar{c}_i$  and  $i$  indicates the benchmarking firm. Recall there are many competitive firms in this industry. With cost level of each firm equal to its marginal cost, the regulator will use the benchmarking firm price which is assumed to be efficient to set the industry price. Assume the regulator commits itself to the price and transfer rule, then

$$T_i = \bar{R}_i \text{ and } \bar{c}_i = p_i \quad (1)$$

Where  $\bar{T}_i$  represent the transfer rule,  $\bar{R}_i$  stand for cost-reduction expenditure and  $p_i$  is the set price. A sample of countries using this methods are Great Britain, Germany, Netherlands, Denmark, Finland, and Sweden in their electricity distribution companies. This approach intend to promotes best practice has it does not allow inefficient cost choice by any firm influence the set price.

However regulator could employ another approach, a price cap is achievable when firms operating in the industry and consumers interest are equally weighted in the regulator's objective function. For example, the case of Californian electricity distribution in 2000 and 2001. The regulator fix a price cap for the sales of electricity to retail consumers, but when the price in the spot (wholesale) market rose above the fixed price (retail price) the regulator fails to adjust the price which led to bankrupt of the distributors and result into big black out in the state of Californian often refer to Californian electricity crisis (Cowan, 2002).

Incentive regulation has played an important role in the on-going regulatory reform of network industries. However, the weakness of this theory is that it is difficult to measure its economic impact and there are no guarantees of its success in the restructuring of network industries. This gives rise to another theory that investigated the inherent characteristics of the industry.

## **2.5 Regulatory reforms towards rules-based regulation**

### **2.5.1 The theory of Monopolistic Bottlenecks**

Baumol (1982) argued that only industries characterised to require high sunk cost and provides essential services (i.e. often referred to having natural monopoly cost functions) should be subjected to regulation. So infrastructure facilities based on physical attributes such

as natural gas, electricity supply, water supply and sewage treatment or railway networks are referred to as having a monopolistic bottleneck.

However, in terms of electricity supply, only transmission and distribution networks fulfil the conditions of a monopolistic bottleneck, while generation (production) and retail (consumption) can be regulated (Walz and Schleich 2009). Maxwell, Lyon and Hackett (2000) suggested that physical networks, such as pipelines and distribution wires (lines) connecting consumers to the system, should continue to be regulated *monopolies*. But the big challenge to policy makers in the industry is how best to govern the vertical relationship with the competitive ‘upstream sector’, which consists of markets for natural gas, electricity and telecommunication.

The theory of monopolistic bottlenecks is central to the disaggregated regulatory approach. It is based on Stigler’s concept of barriers to entry and identifying network-specific market power, which helps in determining the minimum basis for regulation (Knieps, 1997a, b). Its main objective is to develop a coherent approach to access regulation, based on the principle of network economics. Thus, this method can be used in all network industries, regardless of their historical or institutional background (Baumol and Willg, 1999, p.44; Laffont and Tirole, 2000, p.98; Kuhlmann and Vogelsang, 2005, p.34).

However, there are conditions to be fulfilled for a facility to be regarded as a monopolistic bottleneck. They are as follows:

- i). If a facility provides a service to the end user (customers), and if there are no second and third such facilities in existence, we conclude that there is no *active substitute* available.
- ii). If the facility cannot be duplicated in any economically feasible way, then there is no potential substitute. These refer to the costs of the facility as *irreversible*.

Furthermore, the whole value chain has to be examined in order to distinguish those network aspects that have bottleneck characteristics and those that are non-bottleneck. Non-bottleneck chains allow competition, even with or without technological differentiation, product differentiation and innovation. For instance, if there exist alternative products that the service provider can choose between then there is no monopolistic bottleneck. Nevertheless, if economies of scale are relevant and sunk costs are not involved, then the market is competitive.

Consequently, in network-specific markets natural monopoly can only exist when there are no irreversible costs involved (Weitzman 1983). But fixed cost and economies of scale play an important role in these areas. Although irreversible cost is no longer relevant during decision making for established firms in the industry, it is for a potential competitor who has to decide whether to invest (given such irreversible costs).

### **2.5.2 Monopolistic bottlenecks and the concept of essential facilities**

In network areas, where competition is involved, the concept of essential facilities is of crucial importance. This concept was first introduced in US Antitrust Law and was later introduced into European competition law as well. For facility or infrastructure to be regarded as essential, then the following conditions must be fulfilled:

- It is not possible for a supplier to a network services market to duplicate this facility.
- There is no close substitute available.
- It is difficult for a potential competitor to enter the market. (Areeda and Hovenkamp, 1988).

## **2.6 Disaggregated monopolistic bottleneck regulation**

### **2.6.1 The need to regulate third party access**

In this section, we differentiate between private bargaining of access conditions among competitive networks services and regulated third party access to monopolistic bottlenecks. In this theory we expect private bargaining of access conditions between the different networks suppliers under competition leads to economically efficient solutions. We assume strategic behaviour to be undermined because every bargaining individual/partner can easily be replaced by an alternative (potential) network supplier.

Thus, private bargaining solutions on access conditions under competition do not only improve the quality of services provided by the suppliers themselves alone, but it enhances the overall market performance of the network services provided to the end user (customers) (Knieps 2010). However, the problem of inefficiency in terms of access services is becoming of great importance to policy makers, as it can cause a decrease in market shares due to the strong pressure of alternative (potential) network service providers in the industry.

In addition, for competition to be effective in the industry there is the need for non-discriminatory access to monopolistic bottleneck infrastructures. To the level that a

monopolistic bottleneck is observable, ex-ante regulation should be in place. Otherwise, the evolution of service markets will be ineffective. Also, innovative ways of combatting existing bottlenecks should be encouraged and guaranteed in order to allow the evolution of new service markets (Knieps 2010).

Nevertheless, there remain doubts about a concrete solution to the problem of monopolistic bottlenecks. We illustrate this in the case of the power system. Assuming a competitive network in the form of the power system, where there are potential competitors that need access to the power generation and distribution, then these facilities are natural monopolies with sunk costs. Let us assume that this cost is not transferable. So if a potential competitor plans to enter the market with a parallel line, the existing firm could change its strategy by reducing the tariff charge in the short-run. So the short-run variable cost is equal to average cost. Thus, if an entrant (a potential competitor) enters the market, it will be difficult to compete since the incumbent has the market power advantage. A similar situation is observable in other network infrastructures such as railways, airports and gas networks.

### **2.6.2 Monopolistic bottlenecks in the transmission and distribution networks.**

This section examines the fundamental differences similarities in network services –focusing on Natural gas and Electricity supply.

Natural gas is a principal source of energy and power generation. This means that it can only be found (and produced) where the resource reservoirs are. The transportation of gas involves the use of pipelines (or converting into liquefied natural gas (LNG)) from the place it is produced to the region it will be consumed. Pipeline transportation entails a pressure drop (that is pressure drops between the gas entry point and exit point, or between two precisely defined points - e.g. Compressor stations) (Knieps, 2006).

We refer to electricity as a secondary source of energy. Unlike natural gas, electricity can be produced anywhere subject to regulation/approval. It is mainly generated and consumed in the same country, but sometimes can be supplied to other countries. Also, the location of the power stations and the transmission networks are selected to meet the need of the consumers in either domestic/foreign markets (2006, pp.62).

In comparison, electricity transmission routes are not the same as other utility services such as natural gas pipeline routes or railway routes, in the sense that the existence of other railway route does not lead to a congestion problem or involve any form of externality costs

on a given route section (Knieps 2006). But when we refer to power transmission the situation is different as the scope of the externality costs cannot be restricted to the direct transmission line between an entry point and that of the exit points. Rather, it primarily depends on the simultaneous generation (feeding into the system) and withdrawal (at the various entry and exit points) across the overall system parameters (i.e. Voltage restrictions, etc.) in the network system. In other words, it is not possible to transport power directly from a particular point of entry to an exit point, as the current may choose another path through the grid that has the lowest resistance. Since not all the current will choose to transport through the shortest connection (contract path) as the route (or detours), the current does not depend on the transmission capacities and resistances of the different line, but it rather depends on the feed and withdrawal rates at the entry and exit points. (Hogan, 1992, p.213).

In addition, power transmission and distribution can be grouped into different voltage levels. Thus, power transmission refers to high-voltage networks covering regional areas. The main reason to interconnect different power plants is to allow the full utilization of its capacity (economics of scale). Also, the extra high- voltage networks can be used to connect power generators with the local distributors “supplies”.

## **2.7 Reform regulatory scheme and private participation**

The government of both developed & developing countries have long recognized the vital role utility network industries play in economic growth and poverty alleviation. For the past four decades, most governments entrusted delivery of these services to state-owned corporations. But the outcome results were disappointing. Public utility network industries, especially the electric power sector, were plagued by inefficiency (Harris 2003). In this next sub-section, we examine reform and regulation theories and third party access to the electricity sector.

### ***2.7.1 The need to privatise and regulate third-party access to network markets***

Utility network industries such as electricity, telecommunications, natural gas, and the railways have been characterized as either state-owned or private regulated vertically integrated monopolies. For the past three decades, the government have engaged in privatization, deregulating and restructuring of these sectors. The reform programme mainly entails the vertical separation of different segments of the industry, which are assumed to have natural monopoly characteristics and continue to be subject to price, network access, service quality and entry regulations. The argument that privatizing

public utility network industries, especially the electricity sector, is rooted in the principle that if the government establishes credible/independent regulatory institutions (and ensures prices are moderate), then the sector's challenges would have been reduced, if not totally be solved.

However, the important question to answer is under which regime will public utility network industries be better managed: under private ownership or under the state-owned enterprise?

Certainly, if the privatization or regulation framework is poorly designed and/or only partially executed it may negate the expected results or benefits of the reform. According to Galal *et.al* (1994) arguments such as those presented by property right theories or public choice and bureaucracy theories do not apply to every market structure. But De Fraja (1993) showed in his study that under the principal-agent theory, public enterprise performance evaluation and optimal contracts explained the network market better than profit incentive theories.

### ***2.7.2 General description of the Principal-Agent Model***

We assume that if two parties decide to come together for the common good or to enter into a contract there are (or will emerge) informational asymmetries. In anticipation of the existence of informational asymmetries, both parties seek to formulate a contract that will resolve the difficulties that these may cause in the near future. Thus, for this reason, this type of contract design problem is known as the *principal – agent model*<sup>5</sup>. The PA model argues that two important conditions are essential for relationships between principals and agents, based on anticipation of the informational problems that may arise. First, we assume that agents are independent and have the tendency towards maximising their own interests at the expense of principals (Sharma, 1997, p. 759). In other words, there is a general assumption of goal conflict between the principal and the agent.

The second condition is based on the relationships between principals and agents as a result of a problem of information asymmetry. In economics, information asymmetry exists when one party to a transaction holds relevant information but is unable or unwilling to transfer this

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<sup>5</sup> An arrangement in which one entity legally appoints another to act on its behalf. In a principal-agent relationship, the agent acts on behalf of the principal and should not have a conflict of interest in carrying out the act.

information to the other party. Typically we assumed the agent (employee) who runs the day-to-day activity of the firm knows more (to some extent) about the firm than the principal (employer). Both assumptions have become part of mainstream economic theories. The literature illustrates that as a result of these two conditions, two Principal - Agent problems arise: hidden action and hidden information (Lipsey, 1983; Mas-Colell et al. 1995; Eisenhardt, 1989; Wright *et al.*, 2001; Lange, 2005). In practice, the general arrangement is for a principal to pay an agent for his services. Thus, the principal pays the agent for:

i) the agent to act on the principal's behalf, or (ii) the agent to provide some service to the principal.

### ***2.7.3 Strengths and weaknesses of Principal-Agent Model***

The advocates of this theory identify three important strengths: its inter-disciplinary applicability, its explanatory power, and it is result-oriented. First, the theory is applicable to a wide range field of studies. Sorrell et al (2004, p.41) stated that Principal - Agent (PA) relationships “pervade both markets and organisations”. They are of the opinion that the application of a PA theory is important, especially when investigating the problems that exist in relationships that have a principal-agent structure (such in the public utility network industries context). Likewise, a second strength of the theory is based on its explanatory power. For instance, Wright *et al.* (2001, p. 414) pointed out that “*by narrowly focusing on the principal-agent relationship, and with a given set of assumptions, the contribution of this theory is that it provides logical predictions about what rational individuals may do if placed in such a relationship*”. Thus, the theory provides a significant, reliable and empirically testable approach on problems of cooperative effort (Eisenhardt, 1989, p. 72).

In addition, PA theory is based on result – oriented solutions. The major rationale behind the theory is that Pareto inefficient allocation of resources is inevitable. Thus, the theory considers ways in which the relationship between parties (principals and agents) can be made more efficient. That is, agency theory is anchored on improving the contracts between the parties (IEA 2007, p.28). However, it is clear that there is no single way to design a contract that will solve all principal - agent problems. Therefore, when designing contracts, it is suggested that the best contract is one that balances the interests of principal and that of the agent as much as possible. Again, the theory attempts to identify the first-best contract alternatives, and which contract is the most efficient under varying levels of uncertainty, risk aversion, and information asymmetry (IEA 2007, p.30).

Despite the contribution made by the theory to providing insights into challenges faced by Principal - Agents, the theory has some critics (Mitnick, 1992; Lubatkin, 2005; Sorrell, 2004). Their criticism is based on two foundations: Firstly, its inability to portray real-world economic situations, and secondly the incompleteness of the theory itself. Scholars like Lubatkin (2005, p.213) argue that the theory is not able to explain the practical complexities of real-world institutions, despite using complex, technical and highly formalised mathematical models (Sorrell *et al.*, 2004, p. 43). The shortcoming of the theory is due its reductionist stand and its acceptance of three key, but inappropriate, assumptions. These are: First, that opportunism is pervasive, and that people are motivated by more than just money; they also have needs for achievement, responsibility and recognition. People are capable of a full range of actions, varying from self-serving to owner-serving, to altruistic. Second, actors in the principal-agent relationship are portrayed as simply “dispassionate ‘Homoeconomicus’” individuals, whereas people are more complex. And third, the theory is too straight forward and discounts contingencies that may be more reflective of realities in economic relationships.

#### **2.7.4 Agency theory, Principal-Agent problems and Electricity industry regulation**

For over a decade, economists developed economic model based on agency theory to explain the relationship between electricity regulators and operating firms. The theory exposes some problems inherent with regulation and investments in the power sector “which may be understood through the logic of the Principal-Agent problem” (Howarth *et al.*, 2000, p. 482). Indeed, electric power regulation and electricity supply transactions invariably involve the core elements inherent in an Agency theory perspective:

- A principal (in the form of an electricity regulator or shareholder) and an agent (for example, a power producer or electricity suppliers); the problem of tariff divergence between a principal and agent (for example, an electricity regulator wanting to minimise price charged and an energy producer wanting to maximise profit);
- The problem of asymmetric information whereby the energy producer has vital information about the market but does not want to share it with the regulator. For instance, if the producer embarks on a general repair of the distribution networks, but does not inform the regulator of the extent of the repair, and simply transfers part of the cost of the repairs to the customers in the form of utility bills.

Due to the nature of the electricity market, lack of competition and monopolistic bottlenecks, governments subject the sector to regulatory oversight. Some countries do not permit private



owned enterprises to participate in the electricity market because they are profit driven, resulting in the state-ownership of electricity, especially in the developing countries. The rationale is that if the government is managing the key essential sectors (such as the electricity sector) this will lead to optimal results, but in many cases this has proved unsuccessful, as governments are not the best business managers. This has led to a waste of resources. State-owned enterprises (SOE) are inefficient it is claimed, and only tend to satisfy the interests of the political elites (Cuervo and Villalonga, 2000 & Newbery, 2004).

For the last three decades, both developed and developing countries have responded to the problem of information asymmetries in the electricity market by introducing market-oriented reform. In a situation where the agent (the utility firms) know more about its efforts invested in the operation than the principal (in this case the government or regulator), this gap in information is sizable because the regulator are unaware of the technicalities involved in the enterprises.

Secondly, regulators in the electricity market tend to behave opportunistically. This happens when the agent has committed in the form of investment (sunk cost), but the government takes some portion of the value of the investment through nationalisation for its own use. However, in developed countries with strong institutional values, regulation promotes transparency and best practices in the system. A good example is the UK electricity-gas regulation commission (Cuervo and Villalonga, 2000).

Thus, the application of economic theories to electricity regulation, productivity and efficiency require empirical explanation. In the next section, we examine the application of theoretical knowledge to the study of electricity market reforms.

## **2.8 What does empirical evidence suggest on the Electricity Market-oriented reform?**

This section establishes the empirical foundation to the electricity market reform. It highlights the works done so far empirically, in line with our objective, so we only discuss those studies that employed data analysis, (i.e. applying a methodological framework and employing an empirical model for examining the evidence). There is a numerous literature that merely deals with opinion and discussion of electricity industry reform thus that literature is not included here as they do not meet our requirements.

The works reviewed adopted different techniques ranging from cross-country, descriptive and qualitative analyses of power sector reform, others focuses on measuring the efficiency and

productivity of electricity distribution firms and the overall performance of the industry during post and pre reform periods. We also include a brief review of literature from the developed countries experience that may be relevant for African countries. The primary aim of this section is to review and examine the extent of empirical evidence on electricity market reform in both developed and developing countries (Jamasb *et.al* 2005).

### **2.8.1 The Electricity Market**

“Electricity is an essential commodity, a backbone for almost all economic activity and its cost, quality and availability have an impact on the effectiveness of economies, that is any prospects of power shortages, blackout or irregular become major social and economic threat” (Bunn, 2003).

The traditional structure of electricity supply industries almost everywhere on this planet are (primarily) vertically integrated monopolies that were either state-owned or dominantly privately- owned and subject to price regulation and entry barriers. The major components of the electricity sector are generation, transmission, distribution, and retail supply.

Electricity generation takes the form of converting power from other primary sources of energy using a variety of technologies. The underlying principles of electricity generation were discovered between the 1820s and early 1830s by a British scientist Michael Faraday. His basic method is still used today: electricity is generated by the movement of a loop of wire or disc of copper between the poles of a magnet (FEMP 2002). For electric utilities, it is the first stage in the delivery of electricity to consumers.

The second stage is electricity transmission. The transmission network transfers electricity from the point of generation to a substation, using the alternating current (AC) system. In this process, transformers are used to step up, or increase, the voltage that leaves the power plant. This enables electricity to travel over long-distance through wires. When electricity reaches its destination, another transformer would then step down, or decrease, the voltage so that power could be used in homes and factories. This last phase is called distribution.

Electricity distribution refers to stepping down power from high voltage to lower one to delivery to the end users; it involves lowering the transmission high voltage to a medium

voltage ranging between 2kv and 35kv with the use of transformers <sup>6</sup>(Sallam & Malik 2011). The process entails the distribution lines transfers the medium voltage power to distribution poles close to the customer's premises. Then lower transformers reduce the voltage to the usage voltage of appliances and commonly used to supply feed numerous customers through *lower* distribution lines at this point. Commercial and residential customers are connected to the secondary distribution lines through service drops. Industrial or commercial users whose demand is much higher may be connected directly to the primary distribution line or the sub-transmission line. Retail supply is normally organised by individual electric utilities. The firms had de facto exclusive franchises to supply electricity to residential, industrial and commercial end users within a specific region.

The performance of these regulated utilities varies among countries. The sector performance in developed countries was much better than in their developing counterparts (Joskow 1997; World Bank 1994; Besant – Jones 1998 and Bacon and Besant – Jones 2001). The reasons have been due to high operating costs, heavy subsidies, a lack of investment (due to poor returns), poor maintenance of facilities, a lack of an institutional framework, political instability, regular conflicts, a high level of corruption, and electricity theft.

Over the past decades electricity supply industry components (generation, transmission and distribution) were all regulated and subjected to the control of the government, but in the last thirty years or so, ownership and structure in the electricity supply industry have started to become more private than public, and the industry has been exposed to structural and organizational reform.

### **2.8.2 The Liberalization Process**

Change is inevitable, but the transition from state-owned enterprises to competitive oriented enterprises has not been a smooth process for the electricity supply industry. There has been scepticism and concern over the outcomes of liberalization in the electricity sector in many countries. The case of the Californian electricity market crisis of 2000 and 2001 is probably the most evident case (Borenstein *et al.* 2002, Wolak 2003), and the “blackouts in North America and Italy have been used to argue that the electricity market reform is based on a ***try and error*** concept” (Stridbaek, 2006). However, the IEA suggested the reform has recorded many successes, such as the case of the UK, Australia, Chile, Norway, Sweden, Denmark and

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<sup>6</sup> Industrial users are connected to distribution line directly mainly 35kv, while residential and commercial users utilises 2kv and 5kv as the case may be.

Finland (International Energy Agency, 2005). It is pertinent to note that privatising state-owned enterprises is not a condition for reform, neither is the introduction of competition or revising the regulatory framework. However, a combination of economic ideology and an anticipation of sale proceeds has meant that privatisation has become a major reform step and, to some extent, an objective rather than a means to an end (Jamash & Pollitt 2008).

Nevertheless, the decision to privatize a state-owned electricity power sector raises a series of questions about the optimal approach to adopt in transferring assets to the private sector. Should all components (that is; generation plants, high-voltage transmission lines and distribution networks) be privatized, or should private ownership be limited to some aspect of the sector where competitive markets can be feasibly implemented? A number of studies and reports have attempted to answer these questions by suggesting the privatization process as the rationale behind electricity sector reform in different countries, especially among the developing countries. The New Institutional economic theory provides theoretical support and sheds more light on the incentive effects of the privatization process on ownership, structure, organisation and regulation in the utility sector (North 1990; Levy and Spiller, 1996). Other scholars in this school of thought are Niskanen, (1971), Zeckhauser *et al.* (1989), and Boycko *et al.* (1996).

Furthermore, most of the advocates of this policy believed that the implementation of market – oriented reform in the form of structural or organisational changes in the power sector is the ultimate solution. A number of studies have investigated the effects of privatization, commercialization and liberalization of the power sector, although most of the empirical studies focus on developed countries. Vickers and Yarrow (1988) in their study reported mixed results on the effects of privatization. They argued that early studies focused too much on the ownership variable. They rightly pointed out there are other variables that influence the success of the privatization process, such as the market structure, the nature of the market, and the institutional framework. Galal *et.al* (1994) examined the welfare consequences of selling public enterprises, reporting that privatization of network industries in both developed and developing economies have a significant impact economically.

Joskow (1998) suggested that privatisation in the electricity supply industry, especially in the power generation sector, promotes competition in the wholesale (bulk) supply segment through third party transmission access. This could be accomplished while the distribution sector remains a regulated monopoly and a variety of retail options are available to

consumers. However, Pollitt (1997) maintained that economic gains from electricity sector privatisation across different countries of the world are expected to lead to economic growth, citing the success of the UK, Argentina and Chile.

Bortolotti *et.al* (1998) suggested that for privatization in the utility industry to be successful, caution must be applied. Their empirical study, based on the sales of government-owned-utility firms in 38 countries (both developed and developing) over a period of twenty years (1977–1997), found that the institutional variable is a crucial factor when considering privatization in the utility sector. They emphasised the need for an effective regulatory body to assist the government in maximising the sales proceeds to reduce regulatory risk and to help in the smoothness of the privatization process. Hawdon (1996) uses the technique of data envelopment analysis (DEA) to examine the productive efficiency of the power sector in 82 countries and finds that the privatising countries exhibit significantly higher efficiency than the non-privatising countries. Bergara *et al.* (1997) examined the impact of privatization on electricity supply industry performance. They employed eleven variables and two dummy variables (political indices) in their study of the role of the institutional framework in the liberalization process. Their results suggested that credible political institutions are highly and positively correlated with electricity generation performance. This confirmed the basic rationale behind increasing private sector participation, which to a large extent is based on three conditions namely – free entry and exit, third-party access to network facilities, and affordable prices to the customers.

Other scholars have been cautious regarding the economic benefits associated with privatization, especially in developing countries. Among these scholars are Birdsall and Nellis (2003) who examined the winners and losers in the privatisation of the stated-owned power utilities in transitional and developing economies. They employed an orthodox method in assessing the equity (or fairness), efficiency gains from privatisation and the trade - off between asset ownership, employment, returns to labour, access to (and prices of) utility/infrastructure services, and the selling government's fiscal position. Their results indicates that in terms of technical performance, privatisation is considered to be a success in many transitional and developing economies. On other hand, privatisation is viewed as basically bias (both in conception and execution), and this is the view of many developing countries. They are of the view that developing countries are at the loser side, as there are worse off in term of distribution of assets and income in the short-run, while privatisation favours more the industrial users than the residential users.

### ***2.8.3 Establishing Regulatory frameworks in the Electricity supply industry***

The standard electricity market reform model requires countries embarking on reform to establish an independent regulatory body, functioning within a clearly defined legal framework<sup>7</sup>. The regulatory body is planned to provide the “high-quality institution” which permits and fosters sustained growth in capacity and efficiency in the electricity supply industries, particularly in power transmission and distribution segments.

For regulatory agencies to be effective and efficient in the electricity industry it has to be combined with better governance that emphasises (a) making fewer mistakes and (b) having the mistakes identified and rectified more quickly so that (c) good regulatory practice is more readily established and maintained. The difficulties caused by the collapse of some Asian independent power producers in the boom of the early 1990s, and many South American countries infrastructure reforms and concession contracts in the late 1990s, provide some evidence to support the need for a regulatory agency in electricity market reform. This perspective has been at the heart of the recent literature on regulatory governance for utility service industries, particularly the literature that focuses on developing and transition economies. The main advocates of this perspective are Levy and Spiller (1994) and North (1990).

However, the importance of regulation cannot be overemphasised as it is obvious that without regulation in the sector, private investors will consider it too risky and will not invest. ‘Independent’ regulatory bodies are established by the government and provide a well-defined, clear regulatory framework to reduce ‘regulatory risk’ and provide a platform for private investment. The study by Stern and Holder (1999) emphasized the vital role played by the regulatory agency in electricity sector performance. According to them, the regulatory agency acts as a catalyst for structural reform of public utility network industries like the electricity sector. Furthermore, they suggest that for optimal performance in the sector, the regulatory agency must be transparent in their transactions. Cubbin and Stern (2005) assess

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<sup>7</sup> An autonomous regulatory body is not the only indicator necessary for an electricity market, although it is essential. But an independent regulator may be combined with other reforms such as unbundling, competition and privatization. However, establishing an independent regulatory agency has become a prerequisite to attracting private sector investment into the power sector in the same way as an independent central bank has become the standard solution to handle commitment and time inconsistency problems in monetary policy (Cubbin and Stern 2005).

the impacts of a regulatory law and higher quality regulatory governance in electricity industry performance. Their analysis covered 28 developing economies between 1980 and 2001. In their study, they controlled for privatization and competition and allowed for country-specific fixed effects. Both regulatory law and higher quality regulatory governance are positively and significantly associated with higher per capita generation capacity. Their study showed that the positive impact increases in the long-term, as experience develops and regulatory reputation grows.

Using data from the World Bank performance indicators (which contains detailed annual data for 250 private and public electricity companies in Latin America and the Caribbean countries) and the electricity regulatory governance database (which contains data on several aspects of governance of electricity agencies in Latin America and Caribbean countries), Andres, Luis *et al.* (2008) examined the effectiveness of regulatory governance and its impact on electricity sector performance in the region. Their results suggest that the mere existence of a regulatory body, regardless of the kind of ownership in the industry, has a significant impact on sector performance. In addition, after controlling for the existence of the regulatory agency, the ownership dummies variables are still significant and with the expected signs. Thus, they propose an experience measure in the model to identify the gradual impact of the regulatory agency on sector performance and their results confirm that the existence of a regulatory agency has a significant impact on the performance of electricity sector.

There has been little empirical testing of the hypothesis that effective regulatory governance (i) promotes investment and (ii) improves efficiency. So, the task is how to determine, measure or model effective regulation as it is difficult to determine the actual effect(s) of regulatory impact on electricity prices or allocative efficiency, as different countries adopt different regulation policies and obtain divergent results (Jamass & Pollitt, 2000). In the next section, we discuss competition in the electricity market. This includes a review of the recent relevant literature and its relevance to our study.

#### ***2.8.4 Creating Competition in Electricity Market reform***

Are people right to think that competition leads to an increase in productivity, enhances efficiency and improves sector performance? Our study indicates that there are some theoretical reasons for believing this hypothesis to be correct, but they are not overwhelming. Furthermore, while the existing empirical evidence in some developed countries supports the

theoretical perspective, for the developing and transitional countries there is little or no strong evidence.

In a truly monopolistic competitive market, suppliers (firms) cut costs so that they can undercut (rivals') competitors' prices, in so doing they increase their own market share and profits. The benefit associated with the competitive paradigm rests on several assumptions, some of which are applicable in the electricity supply industry, at least in the short run. The first assumption is that there are many similar firms operating in the market, this preventing any single firm from manipulating the market to its own advantage. For instance, a dominant firm could withhold power supply from some of its plants so as to increase its revenue by driving up energy prices, and this could result in a crisis in the industry if not well managed. This was the case in California in 2000 – 2001 (Joskow 2001, p.377).

Similarly, in the early England and Wales electricity reform era, there were only two major private generators, and a lack of competition in the sector persisted. So, in 1994, the sector regulator had to cap pool prices and order an increase in the number of generation firms in order to increase the sector share of competitors/rivals to meet demand. This led the two large generators to divest themselves of some capacity. Studies conducted by Green and Newbery (1992) and Von der Fehr and Harbord (1993) have suggested that the amount of firms needed to achieve effective competition in the UK spot electricity market will be between five to seven firms.

The second assumption is that no single firm can be dominant. Thus, if a single firm controls 60% of generation, this could lead to market manipulation. Such was the case in Norway where the dominant generator temporarily flooded the market with cheap energy, presumably to bring other competitors into line with its own pricing precepts (Bacon 1995, p.135).

The third assumption is that for there to be competition, the operating firms' cost must be structured in a fairly similar manner. For instance, in a system where a firm operates a large hydro dam station that has a dominant capacity, this makes it difficult, if not impossible, for other small firms to compete. Then in such a circumstance there is no incentive for other firms to operate. Therefore, if a single firm has the capacity to operate for a longer period, at an affordable price, then there is no need for competition in such a system (Beacon 1995).

However, in a system with low capacity (i.e. a capacity shortage) as in the case of many African countries, because the plants are old and have been used most of the time without



regular maintenance, the potential gain in market share as a result of competition will be rather small in the short run. But in a system with excess capacity, as is the case with some developed countries, competition will be fiercer. Finally, if a country embarks on market reform in its electricity supply industry and allows new firms access to the market, then the threat of new low-cost suppliers will give incumbent firms an incentive to increase productivity, to seek ways to improve efficiencies and to try to reduce costs.

These assumptions for encouraging competition in the electricity supply industry can be incorporated into the design of policy in the electricity market. For example, in Argentina, the restructured electricity supply industry was designed so that no single generator would control more than 15% of total capacity. However, for some countries grouping generating plants into separate companies that would lead to a competitive structure is virtually impossible. This is so especially if the country's total generating capacity is small; so dividing the system into three or four units of roughly equal size and cost structure will not be profitable. In 1990, for example, 107 countries had an overall generating capacity of 1000 MW, 90 countries are under 500 MW (Bacon 1995, p.135). So, in any of these countries, it will be unwise and unsuitable to introduce a competitive structure. However, opening the market to new investment by allowing new generating firms may be good in the sense it will increase the number of units.

Furthermore, if the generating segment of the sector has the structure and the potential for competition, then it must develop a framework for selling its electricity in a competitive way that transfers this competitive pressure into lower prices. In this case, we assumed that the generator firms sell either directly to the transmission company or to the distribution companies on long-term contracts. Thus, in this case, competitive pressure will come into play only at the time the contract is signed (i.e. one-time competition). After the contracts are signed the pressures to be efficient may be reduced unless they can be sustained through contract terms. However, one advantage of this approach is that even if the generating firms desire to make more profits by raising the energy price, it will not be passed on to consumers until the contract expires or a new one is applied for and is renewed. Based on this principle, the United Kingdom and the Norwegians designed their power sector wholesale power pools in such a way that some power is sold a day before it is supplied, and some time is sold on a contract basis (York. 1994). The Norwegian power pool (which appears to have many features of true perfect competition) has many sellers, but little power is actually sold through the pool (Bacon 1995).

However, to operate the UK or Norwegian model requires considerable sophistication as the system must coordinate the bids to supply at various prices with the demands on the system and the associated settlement plan. To be efficient, the pricing system must be designed in such a manner that it rewards the supply of energy and the supply of power in a way that generates an optimal amount of investment and permits firms to operate at  $MC = MR$  (i.e. cover operating costs). Nevertheless, to operate at this level requires knowledge of how to market the energy, which is complex, as it requires technical expertise. Experience so date suggests that truly competitive power pools will become ever more important in this type of system. Unfortunately, at the moment, such systems are only suitable for large and technologically advanced countries.

In addition, studies have shown that many countries have introduced competition at retail supply level (Joskow 2006, 2007; Bacon 1995; York 1994; Jamsab *et al.* 2005). In such a system, large consumers are permitted to buy from any distributor at unregulated prices. For example, in the UK market, the size threshold was reduced to 100 KW while there were approximately over 50,000 customers in this category in 1995. In 1998, the UK regulator removal size limit.

Based on the above perspective, it is clear that when a country introduces market-oriented policies in her electricity sector it will create competition, especially in generation and retail supply sectors. In general we expect, by allowing independent producers (IPPs) access to power generation, this will improve the quantities of electricity generated and will expand the installed capacity. Also, it is expected that the production cost will fall, due to enhanced technical efficiency, so price falls and the quantity demanded increases. Thus, competition is likely to have a positive effect in both electricity generation and capacity expansion.

### ***2.8.5 Unbundling within the Electricity Market***

The logic behind unbundling is that it enhance efficiency and attract high number of private sector investors when separated into different independent entities (generation, transmission and distribution). We will highlight the impacts of unbundling<sup>8</sup> based on the available examples.

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<sup>8</sup> There are basically two main types of unbundling in the power sector; vertical unbundling and horizontal unbundling. However, horizontal unbundling are not common in developing regions such as in Africa continent.

First vertical unbundling exposed the inefficient segments of the power sector prior to unbundling. It shown that the power sector in developing countries faces high operational losses - an index of an inefficient operational system (companies made up for the losses by using part of the reserve/plant generation capacity to dispatch higher amounts of electricity into the system). However, unbundling implies that the generation, transmission and distribution segments now have to minimize electricity and financial losses to meet agreed target levels as well as delivering at the in terms of economic performance. In each of these cases, the regulatory system and price setting mechanisms must be utilised in driving companies involved towards increased energy efficiency in all three segments. Cropper et al. (2012) found that vertical unbundling significantly improved average annual electricity generation availability by about 4.6 percentage points and reduced outages by about 2.9 percentage points in Indian states that unbundled before 2003. They also suggested that restructuring has not improved thermal efficiency. This may reflect the fact that vertical unbundling has not yet attracted sufficient private investment into the Indian electricity market compared to that of a developed country like the United States.

Kwooka (2002) studied the economies of coordination between generation and distribution in 150 U.S electric utilities. He concludes that the least integrated distributors had significantly higher costs on average than the most integrated utilities (\$6.27 cents per kWh as against \$45.35 cent per kWh). This increase is attributed to utility size; that is a small-sized utility exhibited diseconomies of coordination. Meyer (2010) employed a frontier analysis to examine the economies of scope between the vertical integration of electricity supply industry in the U.S. electric industry. His study suggests that the costs of separating the electricity segments (as compared to its integration) are again related significantly to the size of the utility. That is, for larger utilities the cost is lesser than smaller utilities. So, in effect, if unbundling in the electricity market is to be effective and efficient, market size is important.

However, besides the significant impact of vertical unbundling, there are some shortcoming associated with method to be considered. First, it led to the duplication of management duties among different segments. Also, separation of segments entails for instance that the distribution utility is at liberty to obtain electricity from different sources. Since the observed response of distribution companies to increases in electricity demand appears to be to seek

additional suppliers to meet demand (rather than embarking on demand-side energy efficiency programmes)<sup>9</sup>.

## 2.9 The Econometric study of electricity market reforms

It is important to note that analysing electricity market reform can be complex, because reform in the electricity market can take many different forms, involve a number of interrelated procedures and is an ongoing process. While more than half the world's countries have engaged in electricity market reform, even among the leaders, power sector reform remains ongoing (Kessides, 2012). In these situations, evaluating the performance of market-oriented reforms is difficult because what is being analysed is so often incomplete, even on the terms set by national governments for their own reforms.

Which gives rise to the nature of the industry and the fact that in some countries reform are on-going, any attempt to carry out an evaluation of the impact of the market-oriented reform on electricity market performance based on econometric analysis in some sample of countries may not produce good results, even with a country specific study may not allow for a clear set of lessons to be identified. For the supporters (advocates) and critics of market-oriented reform, this complexity poses different problems. For advocates, it may be hard to produce strong evidence that power sector reform is clearly the best option to improve quality of service. On the other hand, for the critics, it may be hard to find clear evidence of market-oriented reform. Thus, the proponents of the reform will always argue that most countries engaged in the reform have not properly implemented the full package of the reform and it is too early to draw conclusions, especially on the developing countries experience. While the antagonists will always make reference to cases where reform has significantly failed, for instance, the state of California energy crisis of June 2000 to May 2001 is seen as a classic case (Joskow 2001).

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<sup>9</sup> For instance in the case of Ghana, the distribution company was charged by both generation and transmission company for energy delivery (kWh) and not for energy demanded (kW). In such a case, the every distribution company are not interested or do not care about power efficiency. Since charging distribution companies for energy demanded, as a way to address the low efficiency in the network could be that of fixing the amount of electricity allocated to the distributors from available power generating capacity to a certain every period of time (e.g. 1-2 years), after which it will be reviewed. This may enhance the efficiency of the distributors as it would be in their interest to deliver effectively so as to maximize energy sales. It would also serve as an incentive for improved efficiency if a parameter linked to the efficiency of the distribution was incorporated into the tariff calculation formulae (UNIDO & REEEP, 2006)

At this point, it is useful to point out what has driven electricity reform in the first place. Electricity market reform is as a result of the failure of the state-owned power corporations to deliver (Helm, 2004). Thus, by the early 1980s, the power sector in developed countries was characterised as having excess capacity, having made expensive technology choices, and was productively inefficient. At the same time in developing countries, there was a mismanagement of resources, frequent power outages, and the need for massive investment in generation and the extension of networks (Bergara et al., 1997). In these circumstances, market-oriented reform becomes necessary. The primary purpose of electricity reform was to improve efficiency in developed countries and for developing countries it was to improve the access and reliability, and to attract private capital to the sector. Modern electricity reform began in Chile (1982), the UK (1989) and Norway (1990), and has spread to other regions of the world since then (Pollitt 2009).

Despite the aforementioned difficulties associated with modelling reform performances, there are studies that have investigated the impact of electricity market reform. In this subsection, we only review selected empirical papers that give insights into how to model and estimate the impact of electricity market reform, as each of the empirical chapters of this study has its own specific literature review section.

The study conducted by Steiner (2001) constitutes one of the earliest empirical studies that used cross-country and time-series variation to examine the impact of market reform indicators (regulation and market structure) on efficiency and electricity retail prices. She examined the effect of regulatory reform on the retail prices for large electricity customers by comparing the ratio of industrial price to residential price, using panel data for 19 OECD countries for a ten-year period (1986-1996). The study used variables such as electricity price, the ratio of industrial to residential electricity price, capacity utilization rate and reserve margin. She separately estimated the effects of Unbundling, creating a wholesale power pool, and offering third party access to transmission and distribution. Her results suggested that industrial customers benefitted more in terms of cheap price rate than residential counterparts. The study concludes that unbundling does not lead to lower prices in general, but is associated with a lower industrial price ratio, a higher capacity utilization rate, and lower reserve margins.

The study conducted by Henisz and Zelner (2002) adopted a different approach. They investigated the impact of pressure (interest) group competition on the infrastructure

investment decision, focusing on the electricity supply industry. Their analysis was anchored on two hypotheses: Firstly, that a utility with strong pressure group competition will invest more when the political constraint is high. Secondly, if operating in a politically unstable environment, a utility will invest less when facing weak pressure group competition. Independent variables used were: industrial representation<sup>10</sup>, Political constraints<sup>11</sup> were measured by a dummy variable assigned the value 1 or 0 (if the political constraint is high it is equal to 1 if the political constraint is low it is equal to 0). Existing penetration level, demand growth, financial constraints and availability of foreign supplies are the independent variables, while the dependent variable was installed capacity.

The econometric specification adopted by Henisz and Zelner (2002) in their analysis covered 78 countries for a period of twenty-four years (1970 – 1994). Panel data on electricity investment and policies were used. The empirical findings suggested that the result was robust and consistent with the prior expectations. Specifically, the study concludes that in a society with a strong institutional framework where policies are hard to change, then lobbying by interest groups is less effective. Also, the degree to which political actors can alter policy has a positive and significant impact on investment decision-making.

Holburn (2001) examined the effects of political risk on an individual firm's decision to access specific markets (electric power industry) using a standard probit model as estimated using maximum likelihood techniques. He argued that the experiences of individual firms vary as a result of differences in countries non-market capabilities and political systems. Thus, the impact of political risk on firms will not be uniform. Therefore, firms with high crisis management skills will be more likely to invest in countries with a higher political risk. He constructed hypotheses using firm's decisions to enter a specific country as the dependent variable. Panel data of 122,240 observations was used and the study covered 191 firms in 64 countries for the period of nine years (1990-1999). The empirical findings identified the results were robust, supported the hypotheses, and were consistent with the expected economic signs and expectations. Although, a higher level of political (instability) risk typically discourages firms to enter, the impact is significantly lower for firms with a greater level of international investment experience. In another word firms with experience in monopsony generation markets – where firms engaged directly with government bureaucracy

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<sup>10</sup> Industrial Representation - Measured as the ratio of industrial to total electricity consumption (IR) in a given year. Data used to construct this measure were from IEA (1999).

<sup>11</sup> Political Constraints – Measured the extent to which any one institutional actor (e.g. the executive or legislature in a given country) is constrained in its choice of policies in a given year.

- had a greater propensity to invest in countries with politically unstable environments (Holburn, 2001).

However, the study by Holburn (2001) failed to test whether well-defined and credible political institutions are positively correlated with a firm's investment decision. Our assumption is if a country has an independent regulatory institution, it presents a good platform for investment inflows, so the fears that the host government will alter policies or expropriate an investing firm's profit or assets are low. However, a similar study was conducted by Bergara, Henisz and Spiller (1997) focusing on 40 countries. Their results were significant, but suffered a measurement problem, as they made use of generation capacity as a proxy for investment, which constitutes a major measurement problem (especially as the division of investment between generation, transmission and distribution tends to vary from country to country). Another shortcoming of the study was their failure to include post-reform data, as private investments would be more sensitive to political and intuitional factors.

The study conducted by Fiorio *et al* (2007) examined the impact of electricity market reform on consumers' satisfaction in fifteen selected European Union countries. Their empirical findings suggest that privatization alone does not lead to lower electricity prices, neither does it enhance consumer satisfaction. Moreover, their findings showed that country-specific features do have a higher explanatory power than regulatory variables, and the process of electricity market reform among the selected EU countries is not systematically associated with lower electricity prices and higher consumers' satisfaction.

Nagayama (2007) investigated the effects of reforms in the electricity supply industry in developing countries focusing on three regions namely Latin America, the former Soviet Union, and Eastern Europe. Using panel data for 83 countries covering a period of seventeen years from 1985 to 2002, he examined how reform influenced electricity prices. The findings generated from the models suggest that the entry of independent power producers (IPP), the separation of generation and transmission segments, the establishment of a regulatory body, and setting up of a wholesale spot market had a significant of impacts on electricity prices, some of which are not consistent with prior expectations and signs. He concludes that neither unbundling nor the introduction of a wholesale pool market on its own can lead to lower electricity prices.

Thus, only when the independent regulatory body and unbundling co-exist it can lead to a reduction in electricity price. Also, that the interaction of privatisation, and the introduction of competition in the retail supply sector leads to lower electricity prices in some regions, but not in all. However, studies conducted by other scholars such as Zhang et al (2005) and Holburn (2001), suggested the contrary: that market reform in the electricity supply industry, to a large extent, led to a rise in the price of electricity bills.

Joskow (2008) examined the lessons learned from the introduction of market-oriented structures in the electricity supply industry. He argued that reform in the form of restructuring, deregulation, privatisation, regulation and competition does not guarantee lower prices of electricity. Furthermore, Zhang et.al. (2008) assessed the impacts of privatisation, competition and regulation on the performance of the electricity generation industry in developing countries. The study made use of panel data for 36 countries for the period from 1985 to 2003. Their findings confirmed there were impacts of these reform variables on electricity performance indicators such as electricity generation, generation capacity, labour productivity and capacity utilisation. They argued that on their own, privatisation and/or regulation does not always leads to any gain in performance, but when combined there is some form of positive interaction. They conclude that the introduction of competition in the electricity generation sector lead to an increase in generating capacity and enhanced the performance in general of the industry.

In another study, Nagayama (2009) employed two separate empirical models to analyse the impact of electricity prices on the choice of liberalisation model, and the impact of the liberalisation model on electricity prices. The study focussed on panel data for 78 selected countries consisting of OECD countries, Asian developing countries, former Soviet Union countries and the Latin American countries. The multinomial discrete choice model was used and his findings suggest that electricity prices had a significant impact on the choice of liberalisation model that a country adopts. That is, in other words, higher electricity prices influence the type of reform model countries adopt.

The study conducted by Holburn and Zelner (2010) suggested that contrary to conventional wisdom multinational enterprises do not invest less in politically unstable host countries as they pose greater investment risk. Instead, they argue that multinational enterprises vary in their response to host-country investment policy incentives as a result of differences in their organizational capabilities for assessing such risks and their ability to manage policy-making



decisions. Their study was based on two hypotheses: First, that firms operating from (home) countries characterized by weaker institutional constraints on policy makers or greater redistributive pressures associated with political rent seeking will be less sensitive to host-country investment risk in their international expansion strategies. Second, firms from home countries characterized by stronger institutional constraints or strong redistributive pressures will seek less risky host countries for their investments. They adopted an industry approach based on the resource and capability theories by implying that firms developed market power in order to influence decisions and be able to secure their positions in the market. The shortcomings of this study are that the data they employed exclude observations on firms that are not involved in foreign direct investment at all, the implication is that it may lead to selection bias, especially if the set of variables influencing a firm's decision to invest abroad overlaps with those influencing investment destination choices (Shaver, 1998). Their findings also pertain to a single industry in the early stages of its international development. As firms gain more international experience, the relative influence of the home-country institutional environment and thus the capabilities that it fosters, may decline, and the importance of a firm's international experience may grow (Perkins-Rodriguez, 2005).

Furthermore, one of the key expectations of electricity market reform is a reduction in electricity price. Based on this hypothesis, Erdogdu (2011) examined the impact of electricity market reforms on electricity price-cost margins and cross-subsidy levels, focusing on both developed and developing countries. The study used panel data from 63 selected countries between 1982 -2009 (a period of twenty-seven years). The empirical findings suggest that there is no uniform pattern regarding the impact of power sector reform on price-cost margins and cross-subsidy levels across the selected regions as each individual reform had a different impact on price-cost margins and cross-subsidy levels for each country. Therefore, the outcome of the study supports prior expectations that reform prescriptions for a specific country cannot be easily and successfully transferred to another country without some amendments. Moreover, the study suggests that electricity consumption, the income levels of countries and country-specific endowments (such as natural resources and technological knowledge) constitute other key determinants of electricity price-cost margins and cross-subsidy levels among countries.

Meyer (2012a) examined the economies of scope in the U.S. electricity supply industry and the costs of vertical separation of different unbundling options between the years 2001 to

2008. The study identified three key unbundling models<sup>12</sup> and the research findings suggest that if the generation segment of the sector is unbundled, while transmission, distribution and retail supply remained bundled, the average cost of generation will increase between 19 to 26 percent (Meyer 2012, p.110). Alternatively, if generation and transmission remain integrated and distribution and retail (DRU) are unbundled, there was an 8 to 10 percent loss of synergies. The third option, a splitting of the transmission network (TU) from the rest of the sector, showed the lowest cost increase (approximately 4 percent). Intuitively, while there may be a loss of coordination economies between generation and transmission, this third option leads to the lowest increase in market risk<sup>13</sup>. This result supports previous studies (Brunekreeft and Meyer 2009) which conclude that significant economies of scope exist between the different segments of the electricity supply industry.

In another study Meyer (2012b) reviews the basic theoretical and empirical literature of vertical economies and the costs of separating electricity supply into segments (i.e. the study of unbundling and ownership in the electricity supply industry). His findings suggest that unbundling of pure network monopolies such as transmission networks does not come without a cost, given the coordination economies between generation and transmission. Thus, theoretical and empirical literature suggest that network externalities may hinder investment inflow in the sector, except if there exist market mechanisms (such as local network pricing) to regulate and internalise the external effects (as in the case of the British and Norwegian models).

### ***2.9.1 Electricity market reform delivers long-term benefits***

The increasing importance of electricity in globalised economics cannot be overemphasised as a driver for economic prosperity. Stable and affordable supply of electricity is key for the growth of industries and an essential ingredient for the everyday workings of modern societies (IEA, 2005). To this end, the liberalisation of the power sector is a development path and policy option for both developed and developing countries who have implemented or are considering the market-oriented reform.

Through liberalisation, incentives are created for the more efficient operation of an electricity system that promotes increasing private sector participation, an improving

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<sup>12</sup> Generation Unbundling (GU), Distribution and Retail supply Unbundling (DRU) and Transmission Unbundling (TU).

<sup>13</sup> Market risk occurs as a result of the separation of generation and retail supply in the utility system. It is important to consider this risk when considering vertical restructuring in the electricity supply industry.

electricity generation mix and protect investors and customers against expropriation of assets and monopoly market power. After three decades of market-oriented reform in the electricity market, lessons can now be drawn from the experience of the pioneering countries and regions. Although some these pioneering countries have experienced significant success for a number of years, liberalisation has been shown not be an event, but rather a long process that requires on-going government commitment (i.e. a full-package of reform<sup>14</sup>), as no reform model is complete on its own.

However, for a country to obtain the full benefit of the reform (interaction effects), regardless of its approach to market-oriented reform, the process demands strong government commitment. To large extent political commitment plays a key role, in the absence of that, regulatory uncertainty may well be self-fulfilling and undermine the expected outcome of the reform. Liberalised markets are prompted by competition. Thus allowing private sectors to participate breaks down the traditional vertically integrated utilities. Also, separating each segment as an independent entity promotes the decentralisation of the decision making process and increases labour productivity (*see chapter four*).

In other words, a full reform package shows total commitment of the government to the reform and is a strong tool to ensure continuous development towards achieving effective markets.

## **2.10 Conclusion**

The shortcomings of previous studies show the need for further study in this field. The prescriptions for reform and the analysis of the problems encountered have sometimes been approached using wrong variable specifications, sometimes there are problems of endogeneity, simultaneity and measurement problems. Some of the problems are due to lack of a sufficient data set, although there now seem to be sufficient available data to boost research in this field. We intend to improve on the previous studies by conducting more robust tests, including dummy variables in our model when necessary and also making use of pre and post- panel data of reform variables. Furthermore, we examine the political economy of political institutions and the regulatory agency role in shaping firm's investment decisions in the African electricity power industry.

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<sup>14</sup> A Full reform package refers to a country adopting the four reforms (privatisation, regulation, competition and unbundling).

## Chapter 3

### **The economics of electricity market reform: a cross country analysis**

This chapter presents some snapshots of reform outcomes in different regions of the world, given that there are limited studies that have examined cross-country electricity market reforms using econometric techniques. Here we focus on countries that have adopted electricity reforms and explore the novel characteristics adopted in their reform processes as this can offer potential insights into African electricity reform processes.

The global trend of market-oriented reform in electricity markets simply follows a pattern of private sector participation (especially in the generation segment), competition, the establishment of an independent regulator, and separation of different segments of the industry into independent entities. The process towards achieving all this has been difficult, especially for developing countries. This section covers reform in developing regions of the world (i.e. Latin American electricity markets, Asian markets and African power markets). We also draw on experiences from the developed world (European markets, North America and Australia & Oceania) to inform our analysis.

#### **3.1 Motivation for Electricity Market Reforms**

Power sector reforms in developing economies are undertaken within diverse political, economic, and structural contexts. Many of the reforms were initiated as a condition of securing loans and aid from the international financial institutions (most notably the World Bank) to combat economic crises. Consequently, power sector reforms have taken a variety of forms and paths (Bacon and Besant-Jones, 2001; Millan et al., 2001). Given this background, it is perhaps not surprising that many reforming developing countries have encountered unexpected problems and have only achieved, to some extent, their goals (Jamash, 2006).

**Table 3.1: Drivers of Electricity market liberalisation policy**

<b>Electricity market drivers</b>	<b>Sources</b>
<b><i>Developed economies:</i></b> Due to monopolistic excess capacity of the power utilities, innovation and increasing demand for affordable energy.	<i>i).Economic and political ideological change:</i> Involving private sector in the management of public utilities
	<i>ii).Technological advancement:</i> Breakthrough in innovation such as combined cycle gas turbines
	<i>iii). EU Reform directives:</i> European Union directives to all its members to open their retail markets
<b><i>Developing economies:</i></b> Generally due to poor performance of the electricity sector, poor funding, energy subsidies, lack of investment to expand networks, and a lack of routine maintenance culture	<i>iv).Economic crisis recovery policy plan:</i> As a result of debt and financial crisis, IMF introduced Structural Adjustment Programme.
	<i>v).Conditionality of lending policies and donors:</i> World Bank and IMF made reform a condition for developing countries to access to loan facilities

Table 3.1 shows the difference drivers of electricity market reform in developed and developing economies. The sources of these motives differs also, as developing countries embarked on the liberalisation of the electricity market as an economic strategy to attract increasing private sector investment.

In addition to these differences, reforms in the electricity markets has been pursued under different institutional and structural regimes. Countries with strong institutional frameworks and government commitment experience relative success (such as Norway, New Zealand and Great Britain). Others, especially from sub-Saharan Africa (such as Namibia, Malawi and Zimbabwe) remain a disappointment due to their weak institutional framework and continued government intervention in the process. Moreover, developing countries have tended to mimic the design and model adopted by the developed countries, a model which literally does not fit with their institutional framework (i.e. what works for developed countries with strong institutions may not work for less developed countries with relative weak Institutions).

### **3.2 Electricity market reform; exogenous and endogenous driving forces**

Electricity market reforms are either exogenous or endogenous, exogenous forces refer to the external forces that influence the adaptation and implementation of the reform, especially in developing countries. The majority of electricity market reform in developing countries were as a result of economic crisis. The external forces like World Bank and IMF loan/debit

conditionality in securing/accessing loan and management of debit. The other endogenous or internal forces driving reform related to local reasons, such as the poor performance of state-owned power utilities, which has led to high costs and frequent power outages. Other endogenous reasons include the inability of the public-owned power utilities to secure either the required funds for routine maintenance, or funds for network expansion. Many developing countries power sectors are financially distressed because of poor resource management and low productivity and inefficiency in its management (Besant-jones, 2006).

Historically, most of the developing countries embarked on market-oriented reform of their electricity markets because of endogenous factors. The expected outcome is to improve the quality of service, offer a reliable and affordable power supply, to increase the population's access to electricity, to achieve financial stability, and to increase total net electricity generation and installed capacity.

However, reforming the electricity market could be seen as exogenously given, in the sense that while international financial institutions such as World Bank could only play an advisory role on the reform process, the full implementation of such policy falls solely on the government of the country. For instance under-investment in the industry to a large extent is among the main rationale to why developing countries embarked on reform. Prior to the reform era, the main challenge faced by the industry was the issue of cost recovery and underpricing. Over two-thirds of African power utilities set tariffs lower than cost, with only one-fifth of them charging prices that cover their full capital cost (Kessides, 2012b). As expected, market-oriented reform especially privatisation enhances the revenue of the power utilities (*see Tanzania electricity market reform experience*), but the problem is that countries involved are not under any rule to follow hundred percentage the World Bank directives (Besant-jones, 2006).

In the next section we consider case studies of countries from 6 regions of the world as the objectives for reforming differs among developed and developing countries. In each of the country, studies we seek to key lessons relating to the reform, its achievements, and the challenges faced.

### **3.3. Overview of Electricity market reforms in Latin American countries**

It is generally agreed that it was in Latin America where electricity reform started, and reform has been influential and far-reaching. Prior to reform, the sector was made up of vertically integrated state-owned utilities characterized by low productivity, prices lower than cost, low

access of electric power to rural dwellers, low quality of electricity services, high political interference and over employment. Thus over this period, the electricity supply industry in the region was financially unstable, underperforming and had low investment in capacity expansion and in regular plant maintenance (Balza et al. 2013).

Most, if not all, the countries in the continent have adopted electricity market reform. Some have progressed to the level where a competitive electricity market has been established, such as in countries like Argentina, Bolivia, Chile, Peru and El Salvador (Nagayama 2007). There are also a few countries in the region that still maintain a state - owned vertically integrated electricity sector, like Venezuela.

Studies carried out by McKenzie and Mookherjee (2005) analysed public opinion on the impact of privatization in the electricity supply industry in the Latin American countries of Argentina, Bolivia, Mexico and Nicaragua. The majority of the people interviewed rated the benefits derived from privatization as low, although their study shows that privatization has a positive correlation with reduced poverty in the region as it has contributed to increased access to electricity, especially for the rural dwellers.

Moreover, contrary to McKenzie and Mookherjee's (2005) results, Gaviria (2006) found that the poorest quintiles of the region's households were the most likely to disapprove of privatization in the electricity power sector. Also, in 2012, a public opinion survey by Latinobarometro (2012) indicated that a high percentage of people were dissatisfied with privatized public firms in the three observed Latin America countries - Chile (82%), Peru (67%), and Argentina (64%).

In addition, Estache, Guasch and Trujillo (2003) examined the impact of price-cap regulation on privatized utility firms in the Latin American region. They conclude that lack of "political will" or commitment by the government to effectively monitor the process of regulation did not lead to the expected efficiency gains from the reform benefitting customers. Their findings suggest that countries with a weak institutional setting performed poorly, especially when they set ambitious reform plans. On the other hand, governments of countries with strong, reliable institutional frameworks and sustained commitment to reform fared much better, even with modest reform plans (Tongia, 2003; Heller, Tjong, and Victor, 2004; Jamasb et al., 2005; Besant-Jones 2006; Balza *et al* 2013).

In general, regulatory governance was identified as the key element for improvement in the performance of the sector. In terms of specific country experience:

### *Chile*

Chile is often referred to as the first country that started market-oriented electricity reform. The government of Salvador Allende has introduced an economic reform which involved regulation of power sector, but this was completely reversed by the neo-liberal free market orientation of the Pinochet regime. Realising the importance of cost recovery in the public sector, the military government of Chile in 1982 decided to reform tariffs before the privatisation of the electricity utility industry.

Fisher, Gutierrez and Serra (2004) analysed the impact of market reform in the Chilean electricity supply industry in terms of installed capacity, electricity generation, energy sold, labour productivity and profitability. They found an increase in installed capacity from 4,016 MW in 1988 to 10,045MW in 2000. There was also an increase in foreign investment, a fall in unit costs, a decline in the rate of energy losses, and a rise in labour productivity while the price charged by the operators decreased (although this was attributed to the low fuel price at the time of the research). They concluded that the growth in access to electricity services in the most rural areas was a result of the subsidy introduced by the government. Pollitt (2004) examined the progress and lessons learnt from Chilean electricity reform. He suggested that while the initial market structure and regulatory arrangements did give rise to certain problems, the institutional setting was the key that facilitated the reform process. In fact, his study indicates that Chile's power market successfully achieved its target of lowering electricity prices and offering a reasonable rate of return for investors in spite of the markets being small. Pollitt maintained that Chile was able to achieve this outcome due to a combination of free entry into the generation sector and a price restraint imposed by the marginal cost based bidding system in the power pool (which limited the short run exercising of market power by the three incumbent generators<sup>15</sup>).

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<sup>15</sup> It should be stressed that the particular institutional designs adopted in Chile are a legacy of the economic policies of the military dictatorship. The framework has had economic legacy: an institutional setting that maintained a status quo which protected the property rights of initial owners of capital in the electricity sector.



## *Argentina*

Electricity reform in Argentina followed most of the features of the *standard textbook reform model*. In 1992, the Argentine electricity power sector was restructured with 80 percent of power generation, all the transmission network, and up to 60 percent of all distribution networks transferred to private firm ownership (Pollitt 2008). The state-owned utility corporation was unbundled which led to the creation of five generating firms, three distribution firms while a system regulator (CAMMESA) was established to regulate the industry.

The Argentine electricity reform model was based on the lessons learned from the Chilean experience, especially as regards to full-scale unbundling and allowing competition in the sector. It was meant to dynamically drive down horizontal market power and promote competitive wholesale electricity markets (Kessides 2012). Another novel aspect of the restructuring of the electricity sector in Argentina was that transmission expansion was no longer the responsibility of the state, but rather that of the users, (as the users have to propose, approve and pay for major expansion work to be carried out) (Littlechild and Ponzano 2008; Littlechild and Skerk 2008).

A study by Gonzales-Eiras and Rossi (2007) examining the progress of market reform in the electricity power sector in Argentina finds an increase in electricity access and quality of service. They also suggested that increased access and quality of service in the electricity sector led to a decrease in the frequency of low birth weights and child mortality ratios (although they were cautious about these results).

Haselip et al (2005) assessed the impact of electricity market reform on poor dwellers in the city of Buenos Aires. Their findings suggested that the reform was successful, as wholesale electricity prices dropped significantly from US\$ 48.76/MWh in 1992 to US\$ 25.67/MWh in 1997. As the reform allowed competition within the privatised generation market, it also attracted new market entrants to the industry, the number of firms increasing from 13 in 1992 to 44 in 1997 (Estache et al., 2000).

The study by Nagayama and Kashiwagi (2007) supports the findings of Haselip et al (2003), that the electricity reform in Argentina was successful prior to the economic crisis of 2002. Their study traces the history of market-oriented reform in the Argentine electricity power sector and assessed the progress made prior to, and after, the macroeconomic crisis of 2002.

They suggested that Argentine success was due to the unbundling of electricity supply businesses and the introduction of competition, experience learned from Chile.

### ***Brazil***

The power sector reform in Brazil dated back to 1995 with an electricity act which authorised the privatisation of Electro-bras (Brazil's major electricity utility corporation). Independent power producers were allowed access to the power generation market and the government established a nationwide power grid and a wholesale electricity market. However, the Brazilian government were more cautious in the reform process and the reform was characterised by mixed ownership, limited vertical unbundling, and weak competition in the sector. Moreover, the distribution network was privatised without a comprehensive reform blueprint and before an independent regulatory body was set up (Kessides 2012).

Brazil's experience raises serious questions concerning the efficacy of private ownership of power generation in developing countries like Brazil, where there are a large number of hydro-dams that required coordinated regulation (Kessides 2012; Dutra and Menezes, 2005).

In addition, Mota (2003) examined the impact of market reform on the Brazilian electricity supply industry (ESI) using a social cost-benefit approach from 1995 – 2000. He found that the distribution supply companies recorded huge gains in labour productivity, reductions in average cost and efficiency improvements over this period (*figure 3.1*).



*Figure 3.1: Labour Productivity of distribution and supply businesses in Brazil (1991 -2000)*

For instance, during the first phase of privatization in 1991, real controllable costs declined of R\$1.2 billion, a reduction of 43 percent in the real controllable cost per unit. Likewise, during

1995 -2000 there was a further reduction of R\$477 million. There were also efficiency gains as a result of an increase in labour productivity. They conclude that there has been an improvement in the quality of service since the privatization of distribution companies in Brazil, but they also argued that to sustain it constant and efficient monitoring is essential (Mota 2002).

Mota (2004) subsequently compared the performance of privatised Brazilian electricity distribution network companies against that of some U.S privately-owned counterparts. To measure the efficiency of the respective distribution networks he adopted the benchmarking techniques of data envelopment analysis (DEA) and stochastic frontier analysis (SFA). His findings suggested that Brazilian electricity distribution companies' efficiency is catching up with that of the United States.

### ***Bolivia***

The electricity reform in Bolivia in 1994 took a different dimension, as Bolivia opted for both vertical and horizontal separation. The electricity market reform in Bolivia was a component of the wide-ranging economic reform adopted by the government due to the debt crisis. In 1994, the state-owned utilities were privatised, and the power sector was fully unbundled. A wholesale electricity market was set up, consisting of regulated contracts supported by a spot market, with distribution firms required to buy up to 80 percent of expected demand based on three-year contracts. The state-owned utility – Empresa Nacional de Electricidad (ENDE) the largest power company in the country - was divided into three generation units and a transmission grid. The generation sector was capitalized, while the transmission grid was privatised as a common carrier (ESMAP 2000). Meanwhile, the company in charge of electricity distribution - the Empresa de Luz y Fuerza Electrica de Cochabamba (ELFEC) - the Cochabamba electricity distribution company was privatized, while the Compania Boliviana de Energia Electrica (COBEE) – consisting of electric utility generation and distribution companies were already partly unbundled before the full reform programme was introduced. This arrangement saw the World Bank closely involved in the planning, finance and support of the reform programme (Williams and Ghanadan 2006).

### ***Colombia***

The mid-1990s wave of liberalization reform which has swept across many power sectors in the Latin American countries saw Colombia's power sector benefit from political and economic stability as well as structural and institutional reforms. The industry was

deregulated in 1994 following the enactment of electricity laws 142 and 143 that provide the current framework for the electricity sector. Colombian government control over all aspects of the electricity supply industry - power generation, transmission, and distribution - was broken. The Colombian electricity supply industry reform focused on offering incentives for utility efficiency and productivity levels through the introduction of market competition, independent grid access, and markup price regulation for power distribution. The Colombian reform was inspired by the British reform model (Pombo and Taborda 2006).

Colombia now operates a mix of partly state-controlled utilities companies operating alongside private firms. Power generation (ISAGEN) and distribution networks are operated by several public and private utilities. Two of the country's largest energy companies are state-owned but also are listed on the stock exchange. ISA, who went public in 2000, and ISAGEN (Colombia's state power generation company), which also floated on the Colombian stock exchange. ISAGEN owns and operates five power plants with a total installed capacity of 2,132 megawatts (MW), or 16 percent of the national grid's total capacity (Viscidi 2010).

Larsen *et al.* (2004) examines and evaluates the progress of the Colombian electricity market reform from the period deregulation took place in 1994 to 2002. The Colombia model is of interest as it is one of the most open electricity markets in the developing world. Furthermore, Colombia has had no blackouts since deregulation, in contrast to a number of neighbouring countries in the region. Colombia also managed to impose a regulatory environment that kept investment at a reasonable level. Their findings indicated significant efficiency improvements following market reform. They found a significant fall in the number of employees for each MWh produced, from 0.58 employees in 1997 to 0.49 in 1999, with an improvement of 15% alone in 1999. They also measured system losses in transmission and distribution, which in times past in Colombia had been notably high compared to other countries in the developing world. Their results showed a significant fall in system losses from 22.5% in the year before reform to 15% in 2000.

Another important measure of industry performance tested by Larsen *et al.* (2004) was consumers' satisfaction, analysed by measuring the rate electric/energy bills are paid when due (i.e. establishing what fraction of the bills issued are actually paid on time). Their results showed an improvement in the rate of responsiveness of consumers, the time being cut from an average of 81 days in 1996 to only 34 days in 1999, an improvement of approximately

60%. Such changes significantly improved the cash flows for the distribution companies involved and, together with the increase in people actually paying their bills on time and the consequent reduction in distribution losses, benefited the economy.

Pombo and Taborda (2006) assessed the performance, efficiency and productivity of 12 of Colombia's distribution network companies from 1994 to 2001. They measured performance by contrasting changes in mean and median financial and other performance indicators by Wilcoxon Rank Sum and Pearson tests. Data Envelopment Analysis (DEA) was used to evaluate efficiency. The nature of the dataset allowed the estimation of a Malmquist productivity index, and to review its evolution over time. Their results indicate there was an improvement in the main performance indicators of profitability, input productivity, and output following the reform. Plant efficiency and productivity increased after the reform, mainly in the largest utilities used as benchmarks in the DEA efficiency score measures. However, they found less efficient power distribution companies did not improve after the reform and were not able to undertake plant restructuring so as to catch-up in plant efficiency terms with respect to the Pareto efficient input allocations. They conclude that the econometric results on DEA efficiency scores suggested a positive effect of policy reform.

### *Peru.*

In Peru, the experience of electricity market reform could be described as somewhat mixed. According to Torero and Pasco-Font (2001), the power sector reform between 1994 and 1997 was a huge success. It brought significant improvements in labour productivity, a quality service, a reduction in supply losses and an increase in power generation. At the same time it had a positive effect on the quality of life of the populace through increased access to electricity. For instance, in 2001, the Edelnor electric distribution company has reported 83 percent of Lima dwellers were connected to the national grid.

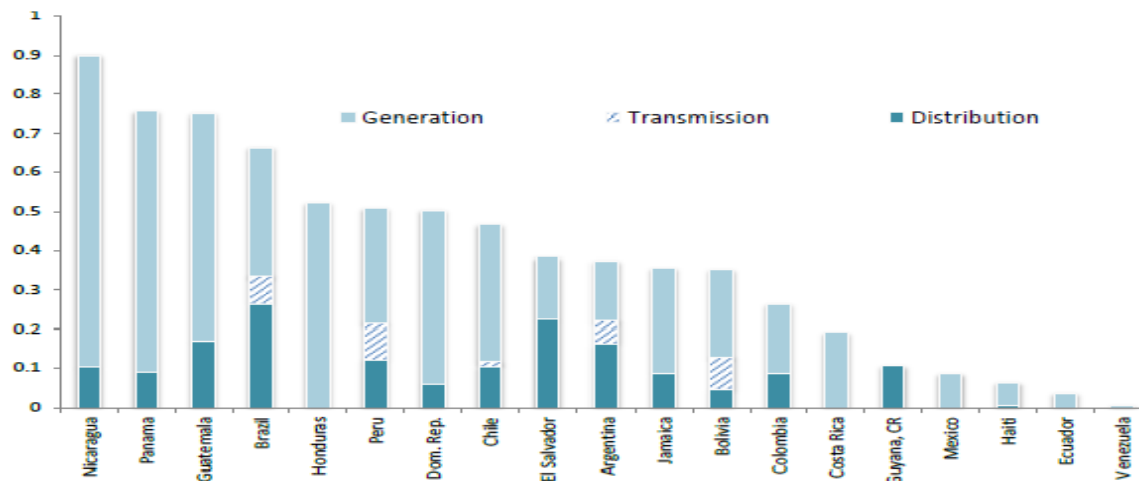
However, comparing the average Peruvian electricity price with other Latin America countries, it appears that while Peru's average electric energy tariff in the residential sector was lower than in either Argentina or Chile, it was higher than that of Colombia and Ecuador (Torero & Pasco-Font 2001).

Perez-Reyes and Tovar (2010) assessed the extent to which the reform of the Peruvian electricity market had improved the efficiency of the 14 distribution companies between 1996 and 2006, using a stochastic frontier approach. Their findings suggest that the reform process

led to the firms becoming more efficient. Moreover, the time trend and private management of the distribution companies were variables that positively contributed to the levels of efficiency.

According to Balza, Jimenez and Mercado (2013), following the reform, the inflow of private investment to the industry has increased, especially in the power generation sector. Figure 3.2 shows the private electricity investment flow in the Latin American region from 1984 to 2011 totalled US\$155 billion, an increase of 38 percent of the average fixed capital formation.

In sum, the argument over the effects and impact of market-oriented reform on electricity market in Latin America is ongoing. Some people suggest that reform has contributed significantly to increased electricity access, and an improved quality of services (Torero and Pasco-Font 2001). On the other hand, others have criticised the reform as contributing to poverty levels in many Latin American countries (Torero and Pasco-Font 2001; Eduardo and Ugo 2002; Estache and Trujillo 2007; Balza et.al 2013). It was in the Latin American region that electricity reform was first started and, until now, it is no easy task to arrive at a definitive conclusion as to the effect of the reforms.



**Figure 3.2:** Figure 3.2: Private Investment in Electricity Power Sector in Latin America, 1984 - 2011 (As a percentage of the average Gross Fixed Capital Formation).

Source: Balza, Jimenez and Mercado (2013)

### 3.4 Electricity Market reform in European Countries

The pre-reform structures of electric utilities in many European countries were mainly based on vertical integration, with the state/municipal authorities owning and operating the electricity industry. The sector was characterised by high regulation with limited competition, thus, customers did not have options on supply. Also, there was no third party access to the

transmission grid (Fiorio *et.al.* 2007). However, the introduction of market-oriented reform in the UK and the Nordic countries in the late-1980s brought a gradual change in the electricity industry in the European Union. In 1996, the European Union (EU) issued the first directive to her member states over the need to open up their retail markets, at least partially, by the Millennium. The directive's objectives were to:

- (i) Have a separation between potentially competitive and monopolistic segments,
- (ii) To offer alternative supply options for industrial and household users, and
- (iii) To increase the autonomy of the transmission networks among the member states.

The short-coming of the EU 1996 directive, however, was that while it did permit the establishment of a wholesale market and/or an independent regulator within member states, it also allowed members to avoid total compliance without any serious penalty. By 2001, fifteen EU countries (except Greece) had opened their retail market (Thomas 2006b). In 2003, a new electricity directive was introduced by the European Union. It emphasised the need for member states to introduce further competition in generation and retail supply while regulating transmission and distribution to avoid the creation of monopolies. The directive was modified in July 2007 to allow member states to include legal unbundling of transmission and distribution networks, permitting the free entry of new firms into the generation and retail supply markets. Member states were also expected to set up an independent arbitrator to regulate the industry.

In 2009, the European Commission adopted another package of electricity market reforms, which aimed to harmonize the two Directives of 1996 and 2003 (Jamasp and Pollitt 2005). This came into force in 2011. The areas the 2009 Directive addressed were that of consumer choice, fairer prices, and cleaner and secure sources of energy supply. The commission intended to achieve their goal by:

- (i) Encouraging member states to cooperate in cross-border energy trade,
- (ii) To improve on the effectiveness and performance of their national regulators;
- (iii) To promote and encourage cross-border collaborations in the areas of research and development,
- (iv) To increase Investment through private sector participation, and

(v) To increase market accountability and transparency on network operations among member states.

The overall aim of the directive was the creation of a strong market-based system; a single European electricity market to promote efficiency and productivity among EU countries. But, due to the reluctance of some member states (who feared domination by larger members), there was a lack of political will power to ensure the full implementation of these measures. Instead, some member states (France, Italy, Denmark, Germany and the Netherlands) still maintain the old model and have switching rates that remain below 10 per cent. In countries like Finland and Spain, switching rates are slightly above 10 per cent, while in the UK and Nordic countries the switching rate is above 20 percent (Defeuilly, 2009).

Despite the European Commission's efforts to develop a Europe-wide single model then, there presently exist different types of ownership, degrees of integration and openness, and market concentration among the member states. So, it is difficult to argue that a unique style of market-oriented reform was adopted by the member states.

### ***United Kingdom***

The United Kingdom electricity reform is often referred to as the *standard textbook model*. Prior to reform, the British electricity supply industry was characterised as been vertically integrated, controlled and operated by a state-owned power utility firm- the Central Electricity Generation Board (CEGB). It was restructured in 1990 under the economic policy of Margaret Thatcher, the then Prime Minister of the Great Britain. The hallmark of the restructuring was the separation of generation and supply from the transmission and distribution grids, with the former under competition and the latter under a regulated monopoly. Generation was entrusted to three companies – National Power, Power-Gen and Nuclear Electric. National Power and Power-Gen were quickly privatized. In 1996 the Nuclear Electric plant was sold off as British Energy (Newbery and Pollitt, 1997) and twelve regional electricity distribution companies (RECs) were established to replace the former area boards (Jamash and Pollitt, 2007). Prior to this, however, the government set up an electricity pool, a market mechanism through which electricity would be traded in the UK. They also abolished the electricity council and created a system of independent regulation, headed by the Director General of Electricity Supply, covering England, Wales and Scotland. This was supported by a regulatory office, the Office of Electricity Regulation (Offer) to regulate the newly private electricity industry. In 1999, the separate regulatory bodies for gas and

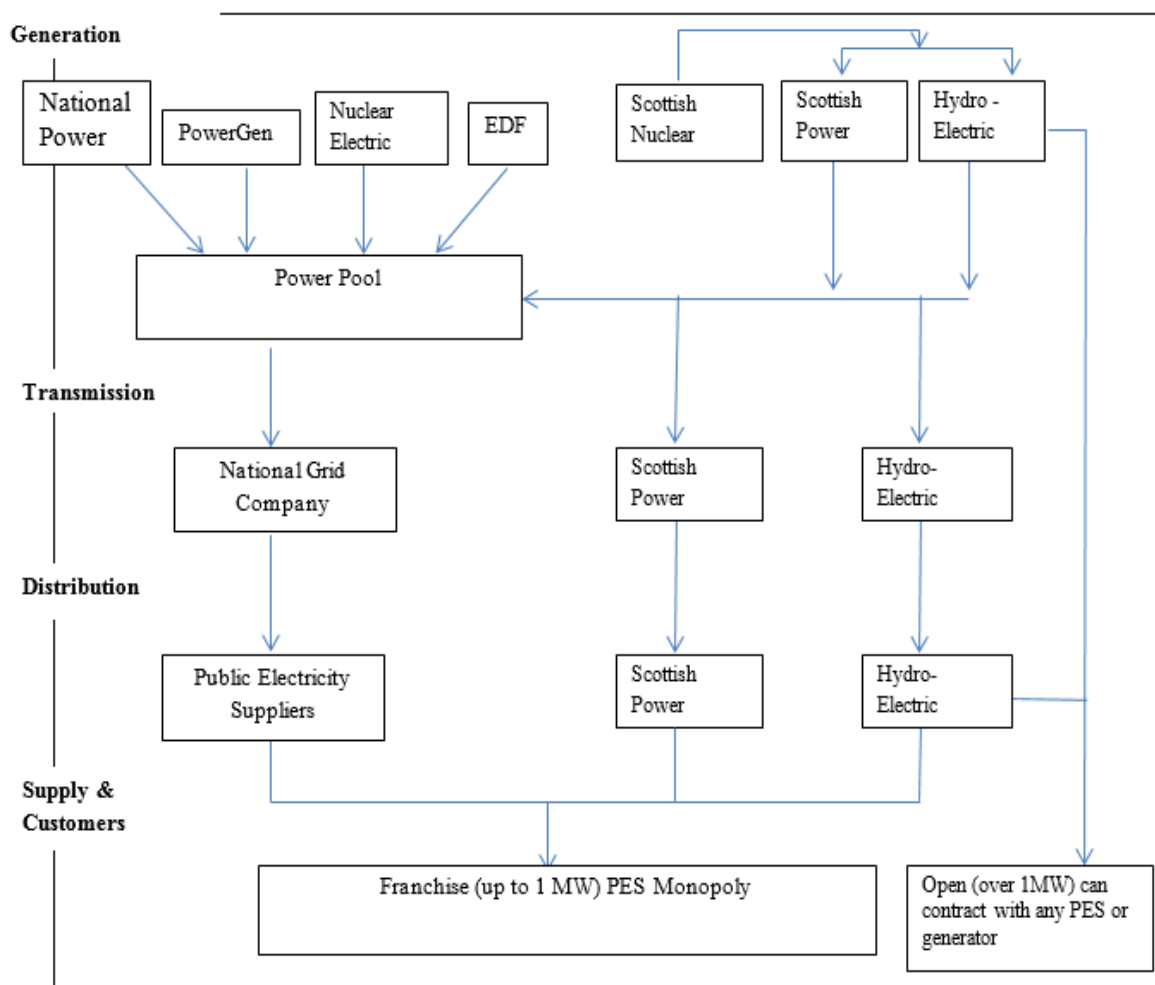


electricity were merged to form OFGEM<sup>16</sup> with the intention to promote competition, regulate price and protect consumers' interest. Furthermore, a series of regional consumer committees, (the electricity consumer's committees), were established to replace the electricity consultative councils (*See figure 3.3*)

Despite the reform, there is evidence market power exists in the generation markets in the U.K electricity supply industry. The markets did not function properly due to limited price discovery, slow market entry (due to uncertainties caused by regulation) and strategic bidding by suppliers (to take advantage of the market design). OFGEM, therefore, stepped up measures accordingly when presented with evidence of market power abuses. Regulatory remedies have included price caps, divestiture to decrease market concentration and the introduction of market abuse conditions into the licences of certain generators (Green 1998; OFGEM 2000; and Wolfram 1999).

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<sup>16</sup> The Office of Gas and Electric Markets – regulatory body in the United Kingdom.



Source: Simmonds (2002).

**Figure 3.3:** Structure of Electricity Industry at Restructuring in the United Kingdom

While these interventions have stabilized prices and did not discourage market entry, they were not successful in reducing market prices to marginal cost.

Domah and Pollitt (2001) conducted a study of the privatisation of the twelve regional electricity companies in England and Wales using social cost-benefit analysis. Their results showed that privatisation had significant net benefits, but that it was unevenly distributed across time and groups in society.

Electricity sector reform in Northern Ireland took a different dimension, as power generation was split into three separate firms, each firm having long-term power purchase agreements with the transmission and distribution network. The privatisation of the generation companies yielded positive results as there was an improvement in efficiency and productivity, although the price of electricity did not come down, nor did the power purchase arrangement have a significant effect on consumers (Jamash et al. 2005).

### *The Nordic countries electricity market reform*

The Nordic electricity market consists of Norway, Sweden, and Finland which liberalized and integrated their respective electricity markets in 1998. Denmark later joined in 2000 (Bang et al. 2012). Between 1991 and 2000, the electricity supply industry of these countries was opened up for restructuring (Amundsen & Bergman 2006). Norway was the first in the region to deregulate its electricity market in 1991 in line with the *textbook standard model*, except it did not privatise the companies created. In 1996, Sweden introduced competition in generation and supply but retained transmission and distribution as regulated monopolies. While Finland liberalised its electricity supply industry in 1995, the path they took was unique in the sense that it was a gradual process; by 1997 there was free access to enter the industry for private producers, thus customers had the option to choose the supplier of their choice. Another hallmark of the Finnish reform was the separation of generation and supply from transmission and distribution, although the distribution networks were not fully unbundled. In Denmark, they introduced market-oriented reform in the power sector in 2000, but it was not until 2001 that it fully liberalised the sector (Bergman 2003).

The reforms were aimed at increasing industry efficiency by promoting competition in generation and retail supply, removing every form of cross-border barrier (such as border tariffs), establishing a common power exchange and increasing the production of electricity (Bang et al. 2012). Table 3.1 depicts production of electricity among the four Nordic countries in 2001.

The integration of the power markets in Norway, Sweden, Finland and Denmark significantly constrained the major power companies' ability to exercise market power within their own national borders. Amundsen and Bergman (2002) examined the impact of co-ownership of the major electricity power companies in Norway and Sweden on the electricity market. Their simulation results suggest that partial ownership among major producers in both countries led to an increase in horizontal market power and a rise in the market price of electricity. The issue of market power arose as the dominant companies tended to use production capacity to take advantage of the consumers, although the possibility of the dominant firms exercising this market power was checked by the independent regulator (Bergman 2003).

**Table 3.2:** *The Production of Electricity by the Dominant Companies in the Nordic Area (2001).*

Countries	Plants/Companies	Production (TWh)	Share of Production (%)
Sweden	Vattenfall	76.6	48.54
	Fortum	29.6	18.75
	Sydkraft	32.7	20.72
	Others	18.9	11.98
	<b>Total</b>	<b>157.8</b>	<b>49.98</b>
Norway	Skatkraft	33.3	27.32
	Norsk hydro	9.8	8.04
	Others	78.8	64.64
	<b>Total</b>	<b>121.9</b>	<b>38.61</b>
Finland	Fortum	40.4	56.42
	Pohjolan voila oy	15.9	22.21
	Others	15.3	21.37
	<b>Total</b>	<b>71.6</b>	<b>22.68</b>
Denmark	Elsam	16.1	44.72
	Energi E2	11.8	32.78
	Others	8.1	22.50
	<b>Total</b>	<b>36.0</b>	<b>11.40</b>

*Source:* Bergman (2003)

### **France**

France started electricity market reform in 2000 following the approval of the law to implement the European Commission Directive of 1996. The reform led to the establishment of an independent industry regulator, a regime of regulated third party access, and the introduction of a wholesale electricity market. The reform opened the industry for more suppliers to enter the market, thus granting the consumer a wide option from which to select their energy supplier. The reform was partial however as the sector is still vertically integrated, with EDF<sup>17</sup> the major producer (70 percent owned by the government). As EDF operates at all stages from generation to transmission, to distribution and to retail supply, the reform is more in the form of an accounting separation between transmission and generation (Heddenhausen, 2007).

### **Germany**

Prior to reform, the German electricity market was dominated by eight firms, but these were merged to form four vertically integrated electricity companies who control 90% of the generation capacity, all aspects of transmission, 75% of the distribution networks, and over 50% of the retail supply (EC-Germany 2007).

<sup>17</sup> Électricité de France S.A. is a French electric utility company, founded on April 8<sup>th</sup> 1946, in Paris, and largely owned by the French government.

Since Germany implemented the 1996 European Commission directive in 1998 the country has seen the complete liberalisation of its electricity supply industry, the abolition of territorial monopolies over electricity generation and supply, and the introduction of third party access. The structure of the industry is controlled by the public electricity supply companies and the private investor, allowing the system to remain both vertically and horizontally integrated.

### *Italy*

The structure of the Italian electricity supply industry is similar to that of France and Germany. In 1999, the government passed a law for the enforcement of the European Commission Directive of 1996. They liberalised the electricity supply industry by creating a state-owned transmission utility operator, then privatising some state-owned power stations of ENEL<sup>18</sup> so as to reduce its control to 50% by 2003. Thus, like in France, ENEL are still involved in all stages (generation, transmission, distribution and retail supply). ENEL control 40% of generation and all aspects of transmission and distribution, except for a few cities where local municipalities control distribution (EC-Italy 2007). The major problem of the Italian electricity supply industry is seen as the sometimes unnecessary intervention of the government.

### *Spain*

Market-oriented electricity reform started in Spain with the passing into law in 1994 of the act that empowered the government to reform the industry. The key features of the reform include; (i) the setting up of an independent joint public-private transmission system regulator (REE) with the aim to regulate both transmission and distribution utilities, (ii) the separation of generation and retail supply, and (iii) the introduction of competition. Later, in 2006, a wholesale electricity market was created known as the Iberian Electricity Market (MIBEL), which united with the Portuguese electricity market to form a single market. The main objective behind MIBEL was to promote collaboration between the two countries, to improve industrial efficiency and to remove any form of cross-border barriers. The short-coming of the Iberian electricity market was the lack of transparency in transactions, so retail and

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<sup>18</sup> Enel, formerly National Entity for Electricity (**Ente nazionale per l'energia elettrica**), was first established as a public body in 1962, and later transformed into a limited liability company in 1992. In 1999, following the liberalization of the electricity market in Italy, Enel was privatized and, as of May, 2015, the Italian government holds 25.5% ownership of the company.

industrial consumers of electricity were worse off under the market as they were paying higher prices. The system also failed to attract foreign investors. Moreover, the major incumbent generation companies prevented new entrants into the system, so the system remained dominated by the three major generation companies (European Commission-Spain 2007).

### *Poland*

Liberalisation of the power sector in Poland can be dated back to the end of the Cold War era when the country transformed its economic ideology from socialism to that of a free market economy. In 1990 it started restructuring the electricity supply industry with the creation of two generation companies, namely New Transco and the Polish Power Grid Company (PSE) to manage generation, while all distribution networks and some generators were merged into joint stock companies which were later sold off (with limits on foreign ownership of 50%). The structure of the industry was both vertically and horizontally integrated, allowing the industry to be operated by state-owned companies and private investors.

The liberalisation process was gradual and, out of seventeen generating companies, only four companies are owned by private investors, while out of thirty-three distribution companies, only one is owned by a private firm. There was subsequently a reversal of the early reform, a re-definition of the role of the independent regulator, and a merger of generation companies (Poludniowy Koncern Energetyczny and the holding company for Belchatow-BOT, the two major firms that produce 50% of the total electricity production in Poland). The reform witnessed an increase in average electricity tariffs by 35% in the first two years, improved cost recovery and the removal of cross subsidies (Williams and Ghanadan 2006).

Kaminski (2011) examined Polish electricity market structure and the effect of market power. The study was based on the structure that was established by the government in 2007, using a game-theoretic model of the power generation market (the PolMark model). The study found evidence of the impact of market power in the Poland power generation sector. The result showed a significant and positive relationship between electricity prices and production volumes. His findings indicate that under the competitive condition the average wholesale electricity price declines by 14.7% and the production volume rises by 6.7% when compared to the reference condition. Similarly, the result confirms the dead weight loss was estimated at the level of 123.6 MV. This implies the value reflects the net social loss resulting from uncompetitive market equilibrium.

### ***Greece***

Prior to reform, the Greek electricity sector was based on a vertically integrated, state-owned company (Public Power Corporation) as the major producer. The liberalisation process started in 1999, with the enactment of a law which seeks to comply with the European Commission Directive of 1996. According to the provision of the law, generation and supply would be separated from transmission and distribution, with the former under free market competition and the latter under a regulated monopoly. The law sought to create a generation pool and a wholesale electricity market (Iliadou 2009). The law came into force in 2001, and the main aim of the reform was to improve economic efficiency in the sector, to increase productivity, to attract foreign investment and to reposition the sector in line with the European Commission directive.

Further amendment of the electricity reform law in 2007 granted all consumers a choice of energy supplier as the law unbundled the distribution network operator and created an independent regulator for the sector. The major operator (Public Power Corporation) still plays a dominant role in power generation, power supply markets and regulates customer tariffs. The government continues to subsidise electricity to the populace, which makes the sector less attractive to foreign investors. Hence, while the Greece electricity industry fully complied with the European Commission directives the structure is still evolving.

### ***Turkey***

Historically, the Turkish power sector was vertically integrated and dominated by the activities of the state-owned company (TEK). In 1982, a law was passed for the abolition of the state-owned company's full control over the power generation sector of the industry. This law allowed private participation in power generation and introduced purchase agreements, allowing independent power producers to sell their electricity to TEK. Two years later, the state-owned electricity company (TEK) was restructured. However, it was not until 1993 that TEK was privatised, being split into two, with one company to manage generation and transmission (TEAS) and the other all distribution networks (TEDAS). In 2001 a full scale liberalisation process was introduced in the Turkish electricity market, as TEAS was restructured into three new state-owned public companies, and generation was separated from transmission. One of the companies (EUAS) has the responsibility to manage the generation, one the transmission networks (TEIAS) and the last acts as a wholesale electricity company (TETAS) (Erdogbu, 2010, 2009 and 2007). Subsequently, the distribution network (TEDAS)

was restructured and divided into 21 distribution regions. Three of them were fully privatised, while the rest remain state-owned enterprises (Chalvatzis and Bora, 2011).

### **3.5 Electricity Market reform in North America**

#### ***The United States of America***

For most of its history, the United States power sector developed based on a state by state level. Each state of the federation has its own electricity industry, normally in public-private ownership. Although the *Federal Energy Regulatory Commission* (FERC), an independent regulatory agency within the Department of Energy, had made some changes in the system (*see Table 3.2*), the United States had never adopted a uniform, comprehensive, federal electricity market reform programme, so has witnessed only limited liberalization and not a fundamental electricity sector restructuring (Joskow, 2008). Electricity regulation in the US is under the control of municipal, state and federal authorities who regulate prices at which electric utilities can sell to retail consumers. Price regulation is anchored on the principle that utility companies should be able to recover costs and make fair returns for the service they provide.

Prior to the 1990s reform, a bulk power system involved three major interconnected networks, namely the Eastern, Western, and Texas power grids. These grids connected electric utilities in one part of the country to another. The early 1990s witnessed the introduction of reforms in the sector because of a rapid rise in electricity prices, and a growing belief that some monopolies were being protected, causing serious inefficiencies in the system (Choynowski 2004).

The reforms initiated were mainly to introduce competition into the wholesale market and among independent power producers and to enhance wholesale power transactions so that retail customers and local distribution networks could afford to buy power from a wide range of sources (*see Table 3.3*).



**Table 3.3:** Major legislative changes in the United States electricity supply Industry.

Act or Order	Year	Description
Public Utility Holding Company Act (PUHA)	1935	Prevented holding companies from controlling large shares of the electricity market
Public Utility Regulatory Policies Act (PURPA)	1978	Increased the competition in the generation segment by requiring utilities to buy electricity from qualified non-utilities (under certain rules and restrictions).
Energy Policy Act (EP Act)	1992	Relaxed the barriers to entry in the generation and eased market exchanges between utilities and other generators.
ORDER 888	1996	Allowed third party access to the transmission network in order to prevent monopoly behaviour by transmission companies.
ORDER 889 on OPEN ACCESS SAME –TIME INFORMATION SYSTEM AND STANDARDS OF CONDUCT (OASIS)	1996	Required an on-line information system to be built to give real-time information to all market participants on transmission capacities.

**Source:** Pineau (2000), and <http://www.ferc.fed.us>

By 2006 many states had adopted one or other form of restructuring in their electricity supply industry and others were planning to do so (Kwoka, 2008). Despite the reform, Sioshansi (2008) argued that the pace of growth in retail supply markets was slow and efforts to introduce a national competitive electricity market have stalled. He cited as causes;

- (i) the California power sector crisis of 2000,
- (ii) mixed outcomes from states that had introduced electricity reform
- (iii) a below par performance of the wholesale market and
- (iv) Congress's nonchalant attitude in pushing for retail competition at a national level.

The California power crisis of 2000 tops the list, as a consequence of which many of the state's electricity generation utilities were declared bankrupt. This resulted in restrictions on electricity consumption, and some parts of the state experienced total blackouts. The California experience is unique to the United States, because it shows that retail tariffs must be set to recover costs and also tariffs should be flexible so as to allow consumers to adjust to changes in prices in the wholesale market. Finally, the market power of the producers has to be closely monitored so as to avoid similar cases in the future.

**Table 3.4:** Summary of the status of Electricity restructuring by different states in the US.

Level	States (date of beginning of retail competition)	Description of the situation
<i>Advanced</i> – Restructuring Legislation enacted (21 states). Although some the states have since suspended their restructuring program.	Arizona (1999), Arkansas (2002), California (1998), Connecticut (2000), Delaware (1999), Illinois (1999), Maine (2000), Maryland (2000), Massachusetts (1998), Montana (2000), Nevada (2000), New Hampshire (1999), New Jersey (1999), New Mexico (2001), Ohio (2001), Oklahoma (2002), Oregon (-), Pennsylvania (1999), Rhode Island (1998), Texas (1998), and Virginia (-)	These states either have retail competition or have a date scheduled in the Act for the introduction of retail competition. Later a standard cost solution is proposed based on state's recommendations.
<i>Recent</i> - Comprehensive Regulatory order issued (3 states)	Michigan(active),New York(active) and Vermont(No)	Implemented retail competition but still not enforced by the law.
Initial-Legislative investigation in ongoing.	Alabama, Alaska, Colorado, District of Columbia, Florida, Georgia, Hawaii, Idaho, Indiana, Iowa, Kansas, Kentucky, Louisiana, Minnesota, Mississippi, Missouri, Nebraska, North Dakota, South Carolina, South Dakota, Tennessee, Utah, Washington, West Virginia, Wisconsin and Wyoming	No schedule exists for retail competition. Regulated monopoly at the distribution and supply level still holds

Sources: *US EIA, 2010.*

### **Canada**

The Canadian electricity market to a large extent resembles that of the United States, insofar as each of the ten Canadian provinces has its own district legislation over the sector. The structure of Canada electricity sector is mainly dominated by government-ownership (*See Table 3.4*). In 1996, however, Alberta introduced an electricity market reform, separating power generation and power supply from transmission and distribution networks. They introduced competition in the former, thus enabling consumers to select their supplier, while the latter was treated as a regulated monopoly. A wholesale electricity pool was also created. Their experience was successful, as the reform led to an improvement in the quality of service, and enhanced industrial efficiency and improved productivity in the sector.

On the other hand, the story was different for Ottawa. Their reform was not successful because of mismanagement and political interference, which led to crisis, and finally the government abandoned the reform programme (Sioshansi 2008).

**Table 3.5:** *The Structure of the Canadian Electricity Market*

Provinces	Vertical Integration	Horizontal Integration	Market Type	Ownership
Newfoundland	Fully	Highly	Monopolistic	Government
Edward Island	Fully	Partially	Monopolistic	Private owned
Nova Scotia	Fully	Highly	Monopolistic	Private owned
New Brunswick	Fully	Highly	Monopolistic	Government
Quebec	Fully	Partially	80% Monopolistic	80% owned by Government
Ontario	Partially	Partially	Monopolistic	Government
Manitoba	Fully	Partially	Monopolistic	Government
Saskatchewan	Fully	Highly	Monopolistic	Government
Alberta	Restructured	Restructured	80% Monopolistic	Government/Private
British Columbia	Fully	Highly	Monopolistic	Government

*Source: U.S EIA 2010, Pineau (2000)*

### 3.6 Electricity Market reforms in Australia and New Zealand

#### *Australia*

The liberalisation of the electricity sector in Australia can be traced to the state/province of Victoria. Prior to reform, the state of Victoria's electricity supply industry was vertically integrated, with a state-owned company operating and managing the sector. In 1991, the state of Victoria introduced a reform programme and restructured the industry. The state-owned company was divided into three companies, with one to manage the power generation, another to operate the transmission networks and the third company took overall responsibility of all distribution networks and power supply. The distribution network was later sub-divided into five distribution companies, while the generation utility was split into seven different companies. In 1994, following the successful implementation of the restructuring programme, the state of Victoria established a wholesale electricity pool. This was merged with the state of New South Wales' wholesale market in 1998. The successful merger of the two wholesale markets gave rise to a national wholesale electricity market.

The market-oriented reform in Australia was successful, as shown by improved industry levels of efficiency, productivity, capital and capacity utilization and a reduction in energy losses. However, the process adopted varies from state to state. In states like New South Wales, Victoria and Queensland full-scale liberalization in the power supply market has been achieved, while the state of West Australia still retained the traditional vertical integration

structure. It is worthy to note, that the largest gainer from the reform process in the Australian electricity market were the industrial or commercial users, as opposed to the retail/residential consumers who experienced little or no change in the real average price of electricity (Abbott 2006).

### *New Zealand*

Prior to the introduction of liberalisation policies in New Zealand, electricity generation and transmission were the responsibility of the Ministry of Energy, while power distribution networks and retail supply were managed by the Electricity Supply Association. Under this structure, the power sector suffered due to inefficiencies which were largely attributed to poor investment decisions, a lack of incentive to improve on the quality of service, and the cross subsidisation of electricity to the populace. In response, the central government passed legislation to establish an Electricity Corporation of New Zealand (ECNZ) in 1987, with the responsibility to coordinate all aspects of the electricity industry in the country. Under the provision of the 1986 Electricity Act, the transmission grid was set up as a separate entity, although still a subsidiary of ECNZ (Choynowski 2004). Table 3.5 below shows the timeline of the ECNZ from its inception to the time it was split. Prior to 1992, all wholesale and transmission activities were managed and operated by ECNZ while retail and distribution<sup>19</sup> activities were managed by 61 publicly owned ‘franchise’ companies.

**Table 3.6:** *Split of New Zealand Electricity Corporation (ECNZ)*

<b>Year</b>	<b>Changes</b>
April -1987	ECNZ was set up as a company under the State-Owned Enterprises (SOE) Act 1986
May-1993	Transmission activity moves from ECNZ to “Transpower”. Transpower was set up to run transmission in New Zealand.
February-1996	Contact Energy commenced by acquiring some of ECNZ’s generators
July-1998	Electricity Industry Reform Act 1998 split ECNZ further into three state-owned generators: Genesis Power Ltd, Meridian Energy Ltd and Mighty River Power Ltd

**Source:** Shen and Yang (2012).

New Zealand introduced further market-oriented reform in her electricity industry in 1998, with a new electricity law which seeks the liberalisation or restructuring of the industry. The law provides the fundamental framework needed to support competition in generation and power supply markets. This Electricity Industry Reform Act saw generation divided into four companies, with one of the companies capturing 25 percent of the total ECNZ capacity.

<sup>19</sup> The Electricity Supply Association is the company in-charge of the distribution networks in the New Zealand in 1990s.

Another feature of the Act was the establishment of a spot market into coordinate balancing, transmission usage and ensure security requirements. However, the experience and the impacts of the New Zealand reform is mixed, although the average national consumer price of electricity has been relatively stable, albeit slightly increasing in recent years (Shen and Yang, 2012).

### 3.7 Electricity Market reforms in Asian Countries

Significant progress had been made in liberalizing the power sector in Asian countries, especially in south-east Asian countries. The main rationale for restructuring was to attract private capital to the sector, to enhance efficiency and to provide a regular power supply to the populace. Reform usually began with promulgating legislation and passing it into law (See Table 3.7).

*Table 3.7: Year of restructuring/policy change for Asian electricity supply industries*

Countries	Year	Electricity Law/Act
Bangladesh	1996	Bangladesh Energy Regulatory Commission act,2003
China	2002	Electricity Act of 1996 amended in 2002
India	2003	The Electricity Regulatory Commission Act 1998,
Japan	1996	Japan Electricity Reform Act of 1996, amended in 2005
South Korea	1998	Electricity Business Act 1998 amended in the year 2000
Philippines	2001	The Electric Power Industry Reform Act of 2001 (EPIRA) The Renewable Energy Act (2008)

*Sources:* Author Analysis

#### **Bangladesh**

Over 35 percent of the population of Bangladesh lacks access to an electricity supply due to poor infrastructure development, poor maintenance of electricity facilities, poor performance, inefficiency and a lack of resource for investing. All these factors caused the government to embark on a restructuring programme in the sector. First, the Dhaka Electric Supply Authority (DESA) was established by the government to manage and operate the electricity distribution system of the capital city Dhaka. In 1992, the Electricity Act was amended to enable private investors to participate in all forms of power generation, except nuclear energy (Gupta, Ferdous and Saleque, 2012).

In 1996, a new reform programme stipulated the restructuring of the sector by allowing Independent Power Producer (IPO) projects to be built on an owner operator basis. A purchase agreement was signed, allowing independent operators to sell power to the

Bangladesh Power Development Board, DESA and the Rural Electrification Board (REB). In 1998, competition was introduced and generation was separated from transmission and distribution networks. Currently, over 1430mw of IPP generating plants have been built and generate about 40 percent of the total Bangladesh electricity supply (Gupta, Ferdous and Saleque, 2012).

Nevertheless, the overriding problems faced by the sector are poor institutional capacity and a lack of skilled manpower. For the sector to improve and meet future power demands there is a need to establish an independent regulator, to create a wholesale electricity market and to promote a favourable environment which encourages foreign capital to invest in power generation and manage transmission and distribution networks.

### *China*

Another country that had made tremendous progress in electricity market reform in Asia is China. China's power sector is second only to the United States in terms of energy production and electricity demand. However, as the past two decades have seen the sector plagued by inefficiency, a shortage of electricity supply and/or unreliable power supplies a decision was taken to restructure the power sector.

In order to attract private capital into the power sector, a separate corporate entity was created in 1977 and assigned with the responsibility to manage (and operate) both the generation and transmission networks. The Ministry of Electric Power were abolished. It was not until 2002 however that the reform kicked-off, with the separation of generation from transmission and distribution. While competition was introduced in generation, transmission and distribution are highly state- regulated. The generation sector was sub-divided into five corporations, and an independent regulatory agency was set up in 2003 to regulate the sector (Du et.al, 2009). Currently, the Chinese electricity supply industry remains dominated by state planning enterprises (at the centre) and decentralized generation utilities (at the periphery).

According to Yeoh and Rajaraman (2004) if China is to achieve a steady power supply and complete its reform process, then it is important to place less emphasis on political and economic expansion, and instead encourage/promote economic efficiency and the well-being of its populace.

## **India**

The Indian electricity supply industry is characterized by ineffectiveness, frequent blackouts, theft, corruption, and has suffered from capacity shortages and uncollected bills. These factors have made the sector financially unhealthy, so frustrating its capacity to invest in a new power system. The condition of the sector was so poor, that industrial users across India have exited the national grid and set up their own on-site power generation plants (Joseph, 2010). This is despite the Electricity Supply Act of 1991 which allowed private investors to invest in power generation and to sign long-term purchase agreements to sell power to the Electricity Board (Choynowski 2004). Following the law's amendment, several states in India initiated reform by separating social obligations from commercial responsibilities. Each state seeks to increase the sector's self-generation of funds and to reduce its reliance on government budgets. Thus, to strengthen the restructuring process, the Electricity Regulatory Commission Act (1998) was passed into law, and led to the establishment of Central Electricity Regulatory Commissions (ERCs), with the responsibility to regulate tariffs for central generating agencies and to also coordinate inter-state transmission networks (*See Table 3.7*).

The 12th Energy Plan (2012-2017) was published in 2012. The Plan highlighted the achievements of the previous Plan, which included the increase in the total number of rural electrification projects to 560,000, extra capacity of 54,964 MW added to the system, and the installation of a further 70,286 circuit km of transmission lines. A total capacity addition of 118,536 MW is planned for the 12th Plan period, including 30,000 MW of grid-connected renewable capacity, comprising of 15,000 MW wind, 10,000 MW solar, 2,100 MW small hydro and 2,900 MW of biomass/fuels (Planning Commission of the Government of India: 2012).

In addition, the 12th Plan targets:

- (i) the creation of a National Grid, through the development of an HVDC connector to the country's Southern electricity grid,
- (ii) an increase in HVDC and 765 kV links throughout the grid to improve capacity.
- (iii) the integration of renewable energy into the power generation mix by increasing renewable energy capacity and providing incentives for low-cost transmission development to connect new renewable capacity.

**Table 3.8:** Status of electricity market reform in the India States

State	Scope of Reforms	Year of Reforms
Andra Pradesh	Generation unbundled, ERC created, Distribution Unbundled	1999 1999 2000
Assam	ERC created	2001
Delhi	ERC created Generation, transmission & distribution unbundled Partial privatization of distribution	1998 2002 2002
Gujarat	ERC created Legislation to allow restructuring passed	1999 2003
Haryana	Generation unbundled ERC created Distribution unbundled	1998 1998 1999
Karnataka	Generation unbundled ERC created	1999 1999
Madhya Pradesh	ERC created Generation, transmission & distribution unbundled	1999 1999
Orissa	Generation unbundled Partial privatization of generation ERC created Distribution unbundled Partial privatization of distribution networks	1996 1996 1996 1998 1998
Rajasthan	ERC created Generation, transmission & distribution unbundled	1999 2000
Uttar Pradesh	ERC created Generation unbundled Partial unbundling of distribution network	1998 2000 2000

\*\*ERC denotes Electricity Regulatory Commission. Sources: (Choynowski 2004)

While the full impact of the reform had yet to be felt, according to Bhattacharya (2012), there remained peak capacity shortages and energy losses, and the government still cross-subsidised electricity for those in the agricultural sector.

### **Japan**

The Electricity Act of 1995 provided the legal framework for the restructuring of the electricity supply industry in Japan. It permitted private investors to invest in the power generating plants, and also participate in competitive bidding in the electricity wholesale market. In order to maintain high performance in the sector, the government monitors electricity prices of each IPP by comparing their performance with others (Nakano and Managi, 2008). The Japanese electricity market reform has also been characterized by caution and its gradualness.



### ***South Korea***

The South Korean government began power sector reform by promoting and encouraging a greater role for private investors in power generation projects in 1998. Prior to this period, the electricity supply industry in the country had been dominated by a vertically integrated state-owned-corporation (KEPCO). In 2001, power generation of KEPCO was sub-divided into five companies, four of these mainly reliant upon thermal and hydropower generation and one for nuclear generation. But in 2004, the government of South Korea suspended its electricity market reform based on a recommendation from the Joint Committee on Energy Policy. They cautioned that the benefits associated with electricity market-oriented reform were mainly theoretical than real. The suspension interrupted the original privatization plan, the introduction of competition in generation utilities and the creation of wholesale and retail electricity markets (Lee and Ahu, 2006).

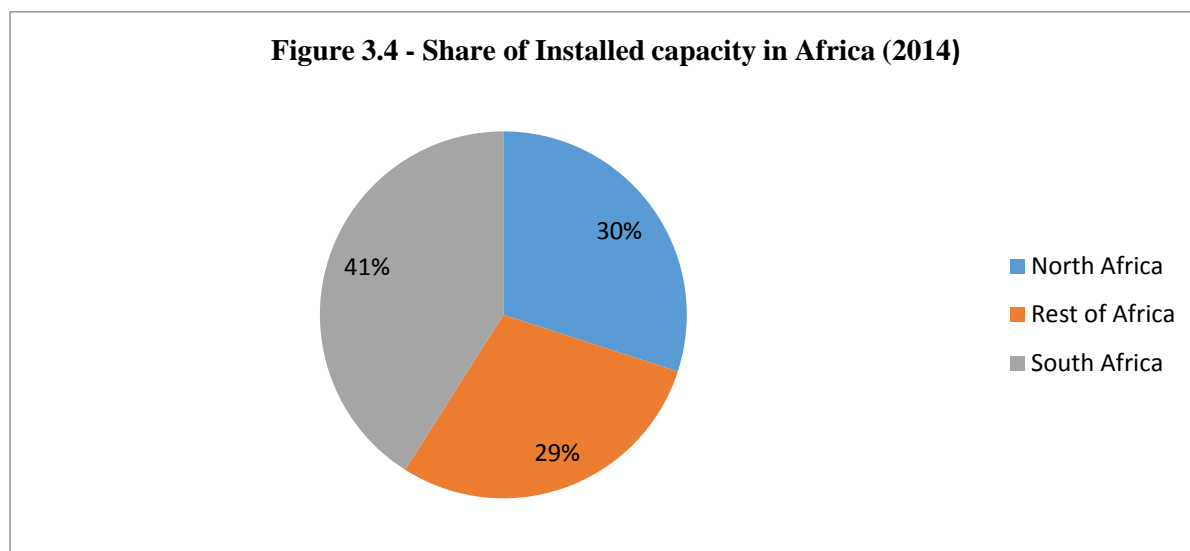
### ***The Philippines***

The introduction of market reform in the power sector in the Philippines started with two executive orders in 1987, which established an energy regulatory board whose responsibilities were to regulate electricity tariffs. In 1992, the board's regulatory function was expanded to include (i) regulating tariffs charged by the National Power Corporation (NPC), distribution utilities, and electric power corporations, and (ii) reviewing and approving private power purchase contracts entered into by NPC and the private utilities. The Electric Power Industry Reform Act was amended in 2001 to allow full-scale liberalization of the electricity industry, with generation utilities separated from transmission and distribution networks. The introduction of competition in the generation sector witnessed an increase in the number of independent power producers granted access to the sector, while transmission and distribution networks remained under-regulated monopoly. An independent regulatory agency was set up, and a wholesale and retail market was created. The wholesale prices were fixed on an hourly basis through a bidding system.

Although the restructuring policy was seen as the right decision, full implementation was a problem, the reform was slow and the customers were yet to fully reap the benefits (Choynowski 2004).

### 3.8 Overview of Electricity Market reforms in African countries

The African Electricity Market is characterized by small systems, with over three-quarter of the region's installed capacity coming from South Africa and North Africa (figure 3.4).



**Figure 3.4:** *Share of Installed capacity in Africa (2014)*

**Sources:** IEA (2014) and World Bank (2014).

Power sector reform in the Africa region has been widespread. There have been attempts to improve the performance of state-owned vertically integrated power utilities, to establish new regulatory authorities, private management contracts and concessions have been awarded, and private sector participation has been sought in the form of Independent Power Producers.

As of 2012, out of 54 countries in the region, 30 had enacted a power sector reform law, while all the countries in our sample (table 3.9) had introduced some form of private participation<sup>20</sup>. Half of the countries had privatized power generation, one-third had privatized their state-owned power distribution utilities, two-thirds had established a regulatory oversight authority, one-thirds had partially unbundled their power system<sup>21</sup> and more than two-third had independent power producers (table 3.8).

However, while about one-third of the countries have adopted three or four of these reform components, few have adopted all of them. In most countries, for example, the state-owned power utilities still maintain their dominant market position.

<sup>20</sup> Except Malawi and Namibia which are without private sector participation (IPPs) yet.

<sup>21</sup> Except Uganda which has full vertical unbundling of their power market structure.

**Table 3.9: Performance indicators of Power sector reform in Africa**

Key Indicators	Number of Countries (%)
Corporatization/commercialization	24 (44%)
Independent power producers	30 (56%)
New electricity Act	30 (56%)
Establishment of Independent regulator	24 (44%)
Unbundling	12 (22%)
Privatization of distribution	12 (22%)
Privatization of generation	15 (28%)

Sources: Eberhard et al. (2008), IEA (2013), AFREPREN (2003), African Energy outlook (2014).

Private sector involvement is either temporary (for example, a limited-period management contract) or marginal<sup>22</sup>. In most cases, the state-owned utility serves as a single buyer of privately produced electricity while still maintaining its own generation plants. Tables 2.9 and 2.10 presents the timelines of the reforms implemented and current market conditions (i.e. showing the percentage of private sector participation) so far in the region.

### 3.9 The Power sector in Africa: Country Specifics

The performance of the power sector in the African region varies widely depending on the level of economic development of a country, the institutional framework, the political environment, the market structure, as well as the approach used to reform the electricity industry. This section provides a detailed overview of the power sector in the region based on the findings of various country studies. African experiences in power sector reform, as will be seen, have been dominated by partial reform; in the form of partial privatization and partial unbundling.

<sup>22</sup> Exceptions are Côte d'Ivoire, Egypt, Mauritius, Morocco, Tanzania and Tunisia, where IPPs have contributed significantly (up to 40%) to overall electricity production. Although Togo is not among the countries considered, the first IPP in the country - Centrale Thermique de Lome, has added 100MW to the grid and nearly doubled national supply (Eberhard and Gatwick, 2011)

**Table 3.10: Electricity Reform Timeline in 30 African Countries**

Country	Electricity Law/Act	Corporatization/ Commercialization	Regulation	(IPPs)	Unbundling	Management/Concession Contracts	Privatization
Algeria	2000	Implemented -2000	Implemented -2002	2002	Implemented(2003)	Pending	Pending
Angola	1996	Implemented -2003	Pending	2003	Pending	Implemented -1997	Pending
Botswana	2003	Implemented -2005	Pending	2007	Pending	Pending	Pending
Burkina Faso	1997	Implemented -2007	Pending	1998	Pending	Implemented -2010	Pending
Cameroon	1999	Implemented -1997	Implemented -1998	2000	Implemented -2001	Implemented -2001	Implemented -2001
Cape Verde	1998	Pending	Implemented -2003	1998	Pending	Implemented -2010	1999
Congo DR	2006	Implemented -2010	Pending	2000	Pending	Pending	Pending
Congo Rep	2003	Implemented -2001	Pending	2001	Pending	Pending	Pending
Cote d'Ivoire	1989	Implemented -1995	Implemented -1998	1994	Pending	Implemented -1990	Pending
Ethiopia	1997	Implemented -1997	Implemented -1997	1999	Pending	Implemented-2007	Implemented -2001
Egypt	1996	Implemented -1997	Implemented -1997	1998	Implemented -2001	Implemented -2001	Implemented -2001
Gabon	1992	Implemented -1999	Implemented -2010	1993	Implemented -1993	Implemented -1996	1997
Ghana	1997	Implemented -1997	Implemented -1997	2000	Implemented -2008	Implemented -1997	Implemented -2005
Kenya	1997/2006	Implemented -1995	Implemented -1997	1997	Implemented -1997	Implemented -2006	Implemented -2001
Madagascar	1998	Implemented -1998	Implemented -2003	1999	Implemented -2008	Implemented -2006	Pending
Malawi	1995	Implemented -1998	Implemented -2007	2001	Implemented -2001	Implemented -2001	Implemented -2000
Mali	1994	Implemented -1998	Implemented -2000	1994	Implemented -1995	Implemented-1995	Implemented-2000
Mauritius	1996	Implemented -1991	Pending	1997	Implemented -1997	Pending	Pending
Morocco	1992	Implemented -1997	Pending	1994	Implemented -1998	Implemented - 1996	Implemented -2001
Mozambique	2001	Implemented -2000	Implemented -2008	2003	Implemented -2000	Pending	Pending
Namibia	1995	Implemented -1995	Implemented -2000	None	Implemented -1998	Pending	Implemented-2001
Nigeria	2005	Implemented -1988	Implemented -2005	1999	Implemented -2007	Implemented- 2013	Implemented-2012
Rwanda	2008	Implemented -2011	Implemented -2011	2011	Pending	Implemented -2012	Implemented-2011
Senegal	1995	Implemented -1998	Implemented -1998	1997	Pending	Implemented - 1999	Implemented – 2003
South Africa	1995	Implemented -2002	Implemented -1995	2003	Implemented -2001	n/a	Pending
Tanzania	2002	Implemented -2003	Implemented -2006	2004	Pending	Implemented - 2002	Pending
Tunisia	1996	Implemented -1998	Pending	1996	Pending	Pending	Pending
Uganda	1999	Implemented -1999	Implemented -2000	2000	Implemented -2001	Implemented-2001	Implemented-2001
Zambia	1996	Implemented -1997	Implemented -1997	1997	Pending	Pending	Implemented-2001
Zimbabwe	1996	Implemented -2002	Implemented -2002	1998	Pending	Pending	Implemented-2002

**Sources:** Each countries utility Annual Report, African Development Indicators (World Bank), African Development Bank, African Infrastructure database (World Bank).

**Table 3.11: Current Market conditions in the African Power Sector (2013).**

Country	Segments/Operator		Utility Company	Capacity in kw (2013)	% Power Sector Share
Algeria	Generation	95% State (S)	Societe Nationale de l'Electricite et du Gaz (Sonelgaz)	15,100,000	5% private sector ownership in the form of IPPs and Concession in both generation and Distribution sectors.
	Transmission	S			
	Distribution	S			
Angola	Generation	70% state (S)	Empresa Nacional de Electricidade (ENE)	1,155,000	30% in form of IPPs and Concession agreement in Power generation and Distribution
	Transmission	S			
	Distribution	concession			
Botswana	Generation	S	Botswana Power Corporation (BPC)	132,000	There is no private sector participation, rather BPC import electricity from Eskom (South Africa).
	Transmission	S			
	Distribution	S			
Burkina Faso	Generation	85% State (S)	Société Nationale Burkinabè d'Electricité (SONABEL)	252,000	SONABEL still dominates the sector, there is little private sector participation in the sector.
	Transmission	S			
	Distribution	S			
Cameroon	Generation	49% State (S)	Société Nationale d'Electricité (SONEL)	1,155,000	AES-SONEL owns and operates a 51% concession over the power sector for 20 years.
	Transmission	51% Private			
	Distribution	51% Private			
Cape Verde	Generation	51% State	Electricidad e Agua (ELECTRA)	89,800	The State owns 51% of Electra, with private companies holding 34%, and municipalities in the country 15%.
	Transmission	S			
	Distribution	51% State (S)			
Cote d' Ivoire	Generation	Concession	Compagnie Ivoirienne d'Electricité (CIE)	1,222,000	The private sector (EDF and SAUR) has a 51% share of the industry, and the state retains the remaining 49%.
	Transmission	S			
	Distribution	Concession			
Congo DR	Generation	95% State (S)	The Société National d'Electricité (SNEL)	2,437,000	There is little private sector ownership. In 2011, the government made an effort to privatize the sector, but this failed due to the extensive damage inflicted on the SNEL's infrastructure during the civil war.
	Transmission	95% State (S)			
	Distribution	95% State (S)			
Congo Rep	Generation	S	The Société National d'Electricité (SNE)	559,000	There is no private sector ownership in the sector.
	Transmission	S			
	Distribution	S			
Egypt	Generation	Concession	Egyptian Electricity Holding Company (EEHC)	26, 910,000	EEHC owned 90% while the remaining 10% are owned by the independent power producers.
	Transmission	S			
	Distribution	Concession			
Ethiopia	Generation	70% state (S)	Ethiopian Electric Power Corporation (EEPCO)	2,061,000	EEPCO controls 70% in generation segment of the industry; the remaining 30% held by the private sector.
	Transmission	S			
	Distribution	S			

Gabon	Generation	49% State (S)	The Société d'Electricité et d'Eaux du Gabon (SEEG).	415,000	SEEG has 49% of the sector while the private sector owned 51% (based on IPPs and concession agreement in generation and distribution).
	Transmission	S			
	Distribution	concession			
Ghana	Generation	61%	Volta River Authority (VRA)	1,985,000	VRA has 61% of the generating sector while the remaining 39% is owned by the private sector in the form of IPPs and concessions.
	Transmission	S			
	Distribution	S			
Kenya	Generation	54% State (S)	Kenya Power (KPLC)	1,698,000	KPLC has 54% of the generating segment while the private sector owned 46% through IPPs and concession agreements.
	Transmission	S			
	Distribution	S			
Madagascar	Generation	65% State (S)	Jiro Sy Rano (JIRAMA)	430,000	JIRAMA control 65% in generation segment of the industry while the private sector retains the remaining 35%.
	Transmission	S			
	Distribution	S			
Malawi	Generation	50% State (S)	The Electricity Supply Corporation of Malawi (ESCOM)	287,000	ESCOM has a 50% share in the generating segment of the industry, with the private sector retaining the other 50% in the form of IPPs and concessions.
	Transmission	S			
	Distribution	S			
Mali	Generation	66% State (S)	Énergie du Mali (EDM-SA)	304,000	A private sector firm (IPS West Africa) holds 34% in mainly generation segment of the Malian utility (EDM-SA) while the remaining 66% are in the hands of the government of Mali.
	Transmission	S			
	Distribution	S			
Mauritius	Generation	46% State (S)	The Central Electricity Board (CEB)	900,200	CEB has 46% in the generating sector, with private producers retaining the other 56% in the form of IPPs.
	Transmission	S			
	Distribution	S			
Morocco	Generation	60% State (S)	Office National de l'Electricité et de l'Eau Potable (ONEE)	6,620,000	ONEE has 60% share while the private sector holds the remaining 40% in the form of IPPs and concession in a generation.
	Transmission	S			
	Distribution	Concession			
Mozambique	Generation	46% State (S)	Electricidade de Mozambique (EDM)	2,428,000	EDM focuses on the transmission and distribution networks, and the Hydroelectric Cohora Bassa (HCB) in-charge of power generation. HCB controls 85% of the total generation while the IPP and other fuel-powered generators generate 15%
	Transmission	S			
	Distribution	S			
Namibia	Generation	S	Namibia Power (Nampower)	508,000	Nampower controls generation and transmission while distribution is undertaken by the City of Windhoek and two regional distribution companies.
	Transmission	S			
	Distribution	Regional			
Nigeria	Generation	20% State (S)	Power Holding company of Nigeria (PHCN).	8,100,000	In 2013, the Nigerian government relinquished ownership of 18 electricity companies held by the PHCN (6 generation and 11 distributions). The Private sector now owns 80%, while PHCN holds the remaining 20%.
	Transmission	Concession			
	Distribution	Private (100%)			
Rwanda	Generation	80% State (S)	Rwanda Electricity Corporation (RECO)	57,000	RECO control 80% in the generation segment of the industry, while the private sector (in the form of IPPs) holds 20%.
	Transmission	S			
	Distribution	S			
Senegal	Generation	40% State (S)	Société Nationale d'Electricité	638,000	The Private sector holds 60% (in the form of concessions and IPPs in the generation

	Transmission	Concession	(SENELEC)		segment) while the SENELEC retained the remaining 40%.
	Distribution	Concession			
South Africa	Generation	95% State (S)	ESKOM	44,260,000	ESKOM control 95% of the total market in generation and the private sector accounts for remaining 5% while the regional companies (municipalities) are responsible for 55% in the distribution and the remaining 45% from Eskom. .
	Transmission	S			
	Distribution	Regional			
Tanzania	Generation	60% State (S)	Tanzania National Electric Supply Company (TANESCO)	841,000	TANESCO control a 60% in the generating segment of the sector, and the remaining 40% is held by the private sector in the form of IPPs and concessions.
	Transmission	S			
	Distribution	S			
Tunisia	Generation	88%	Société Tunisienne d'Electricité et du Gaz (STEG)	3,652,000	With the liberalization of the sector, STEG holds a market share of 88%, while private sectors hold 14%.
	Transmission	S			
	Distribution	S			
Uganda	Generation	20% State (S)	Uganda Electricity Board (UEB)	539,000	In 2001, with the unbundled UEB <sup>23</sup> , the private sector controls 80%, while the state holds 20% in generation and distribution. The state regulates the activities of the sector.
	Transmission	S			
	Distribution	20% State (S)			
Zambia	Generation	94% State (S)	The Zambia Electricity Supply Corporation (ZESCO)	1,679,000	In the power sector in Zambia, there are 3 operators, ZESCO, and two private sectors operators (CEC and Lunsemfwa). In generation (ZESCO 94%, CEC 4%, Lunsemfwa 2%), transmission (ZESCO 69%, CEC 29%, Lunsemfwa 2%) and for distribution (ZESCO 70%, CEC 25% and Lunsemfwa 5%).
	Transmission	69% State			
	Distribution	70% State			
Zimbabwe	Generation	90% State	Zimbabwe Electricity Supply Authority Holdings (ZESA)	2,035,000	There are a few small private sector firms operating (either providing stand-alone systems in remote communities or back-up systems through large urban companies for some schools and hospitals). Government dominates the sector.
	Transmission	S			
	Distribution	60% State			

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\*\* S = State

\*\***Concession** as used here means that the government of various countries entered into agreement with a private firm to manage the sector on their behalf for a certain number of years.

<sup>23</sup> UEB was fully unbundled resulting in three separate companies; the Uganda Electricity Generation Company Ltd, the Uganda Electricity Transmission Company Ltd and the Uganda Electricity Distribution Company Ltd.

**Source:** Each countries utility Annual Report, African Infrastructure database (World Bank) and World energy council database.

### 3.9.1 Status of the Power Sector in Africa

#### *Algeria*

The state-owned vertically integrated Sonelgaz<sup>24</sup> controls all the three main segments of electricity supply (generation, transmission, and distribution) in Algeria. In 2002, a new electricity law converted Sonelgaz into a private company and revoked its monopoly on the power sector, although the Algerian government continues to hold all of the company's shares. In the same year (2002), an independent regulatory authority was created- the Electricity and Gas Regulatory Commission (CREG), to regulate, formulate policies for the industry and also to ensure non-discriminatory access to the networks. The long run plan was to eventually split Sonelgaz into separate generation, transmission, and distribution companies though these plans faced domestic opposition from organized labour (Werenfels, 2002). Government plans to privatize Sonalgaz were not realised, and instead, a joint venture with Sonatrach was created<sup>25</sup>, to form the Algerian Energy Company (AEC), to pursue partnerships with foreign investors.

#### *Angola*

Extensive damage and decades of underinvestment in the power sector infrastructure during the 30 years of civil war (1972 -2002) in the country has caused Angola to suffer from an undersupply of power and frequent outages<sup>26</sup>.

Since the end of the civil war, the government has embarked on a restructuring programme to reform the power sector and reposition it to boost generating capacity, increase access, and to repair and expand the networks to other parts of the country. In 2003, the government, permitted private sector access to the generation segment of the industry to build and operate plants to increase generation capacity, selling their electricity to the state-owned corporation under Memorandums of Understanding (ADB Report, 2014 and African Energy Outlook 2012).

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<sup>24</sup>**Sonelgaz** (*Société Nationale de l'Electricité et du Gaz*), is a state-owned utility in charge of electricity and natural gas distribution in Algeria. Founded in 1969, it replaced the previous body *Electricité et Gaz d'Algérie* (EGA), and has monopoly power over generation, transmission and distribution of electricity, and the distribution and selling of natural gas within the country. As of 2010, it generates approximately 29 billion kWh a year, sells 4.6 billion cubic metres of gas a year, and has a work force of about 20,000 people (Sonelgaz web site).

<sup>25</sup> **Sonatrach** is an Algerian government-owned company formed to exploit the hydrocarbon resources of the country. It also has some oil concessions overseas in Libya, Mauritania, Peru, Yemen and Venezuela ([Sonatrach web site](#)).

<sup>26</sup>Rapid urbanisation and the explosion in informal settlements around the main cities in Angola has driven a dramatic rise in the number of illegal connections to the national grid, further exacerbating power shortages (KPMG 2013).



According to the Angola electricity law,<sup>27</sup> an independent regulatory body was to have been established, to be known as the *Institute for Electricity Regulation (IRSE)*, to regulate the activities in the power sector. However, at the time of reporting, it has been established but is not in operation.

While the Ministry of Energy and Water (MINEA) is responsible for power sector policy formation, coordination and implementation, the main power utility company (the Empresa Nacional de Electricidade - ENE) is a state-owned vertically integrated electricity provider that has historically suffered from an over-dependence on government funding, a low tariff structure that does not cover costs, and the inability to collect revenue from numerous illegal connections (KPMG 2013). ENE manages the transmission network and operates 80% of power generation facilities and the distribution system (outside of Luanda). In the state capital (Luanda), power distribution is managed by the Empresa de Distribuição de Electricidade (EDEL).

In 2012, the government sought regional collaboration with the government of Namibia to increase its electricity supply by undertaking the 600MW Baynes power project, developing a transmission line linking the Angola grid to that of Namibia and, by extension, to the Southern Africa Power Pool (AfDB, 2013).

### ***Botswana***

The Botswana Power Corporation (BPC) is the state-owned vertically integrated national power utility with a monopoly over all the segments (generation, transmission and distribution) of the electricity supply industry. The Botswana government regulates the power sector through the Energy Affairs Division of the Ministry of Minerals, Energy, and Water Resources, which in turn, monitors BPC.

In 2007, the government amended the Electricity Law to facilitate private participation in the power sector. However, there are currently no specific plans to unbundle the power utility. As of 2013, there is only one IPP operating (APR Energy), which operates a 70 MW diesel emergency power plant at Matshelagabedi. The lack of full reform in the sector has contributed to the following:

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<sup>27</sup> A/96 of 1996 (General Law of Electricity) and Lei General de Electricidade, Lei No. 14

- There is no systematic reserve generation capacity and, since 1992, Botswana has imported large quantities of electricity. In 2008, about two-thirds of its total electricity consumption was imported from South Africa (BPC Annual Report 2012).
- Only 49 percent of Botswanans are connected to the national grid. Although BPC increased residential connection at the rate of 13 percent per year from 2002 to 2011, this is not yet enough (BPC Annual Report, 2012). BPC is currently expanding its coal-fired generating capacity by about 1,200 MW to compensate for the downturn in the availability of power imports from South Africa. The first phase, a 600 MW plant, started in 2012 (Vagliasindi and Besant-Jones, 2013).
- The financial performance of BPC has not improved. For instance, in 2011, the total operational cost of the three segments (generation, transmission and distribution) rose by 25%, driving the average cost to 85 thebe/kWh. The net effect was a 22% increase in total operating costs, against an 18.2% growth in revenue (BPC Annual Report, 2012).

Currently, two-thirds of the electrification network in the country is concentrated in the eastern part of the country and does not reach the more sparsely populated areas in the central and western regions of Botswana. This has prompted the government to improve the electricity supply in rural areas through the Renewable Feed-In Tariffs (REFIT) policy, which was approved in June 2012. This policy was expected to subsidise renewable energy production, oblige BPC to purchase electricity produced from renewable sources at cost-reflective prices, and increase production and grid connection opportunities for small renewable power generators. However, as of 2014, the REFIT Policy is still to be implemented.

### ***Burkina Faso***

The Société Nationale d'Electricité du Burkina Faso (SONABEL) is the state-owned vertically integrated power supply utility. SONABEL controls all the three main segments of electricity supply (i.e. generation, transmission and distribution). Although the electricity law of 1998 was approved so as to break the SONABEL monopoly, it is yet to be fully realized. In 2004, the generation segment was opened to private sector participation so as to promote competition while transmission and distribution remain a regulated monopoly.

In 2007, a law<sup>28</sup> regarding the regulation of the electricity sector in Burkina Faso was enacted, based on the recommendations of the PPIAF studies<sup>29</sup>. This provided for the creation of a new regulatory authority, *the Autorité de Régulation du Sous-Secteur de l'Électricité (ARSE)*<sup>30</sup>, but it is the Ministry of Trade is responsible for setting electricity tariffs in the country. However, the overall generation capacity in Burkina Faso is below 80 MW, with 70% of this supplied by thermal power stations. There is no national transmission network and the distribution network is limited. Given the growing demands for power, and the high cost of using diesel oil to generate power in Burkina Faso, the government is seeking to import electricity from neighbouring Côte d'Ivoire and Ghana. In 2000 only 6.9% of the country's population had access to electricity. However, the situation had improved to 13.1% by 2012 (World Bank Report, 2013).

### **Cameroon**

The national utility company - *Société Nationale d'Électricité* (SONEL) - controlled the three core segments of the power industry in the country. Yet in 1990, only 29% of the total population were connected to the national grid, a figure that increased to 49% in 2010 and in 2012 it was 53.7% (World Bank Development Indicators, 2014). The regions that suffer the most from a lack of electrification are those with large rural concentrations, notably Adamaoua, the East, Extreme North, North, North-West, and South-West regions, where access is 10 percent among the poor and 33 percent among non-poor populations.

In the late 1990s, the government of Cameroon recognized the need to restructure its power sector<sup>31</sup>, as economic growth had seen electricity demand grow quickly from both households and industrial users (and particularly from ALUCAM, an aluminium smelter that consumed approximately one-third of the total power supply). Moreover, as SONEL suffered from poor collection rates and low tariffs, it faced a growing debt burden which it was unable to service. In response, the government embarked on a series of power sector reforms, starting with the amendment of Electricity Sector Law in 1998 which laid the groundwork for the privatization of SONEL (IFC, 2012 and PPIAF, 2012). The same year, an independent regulatory agency

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<sup>28</sup> Electricity Law no. 027-2007/AN of Burkina Faso.

<sup>29</sup> World Bank Public-Private infrastructure advisory facility.

<sup>30</sup> Decree no. 2008-369/PRES/PM/MCE/ MCPEA, On April 16, 2010, the five members of ARSE were appointed for a five-year term.

<sup>31</sup> Due to low generation capacity and access to electricity coupled with increasing in population. Dependence on hydropower has left the Country vulnerable to drought.

(ARSEL - *Agence de regulation du Secteur de l'electricite*) was established to regulate the entire sector, formulate policy and issue licences/permits to prospective private producers.

In 2001 SONEL was privatized and a private American firm (AES SONEL) acquired 51% of power generation and 51% of both transmission and distribution segments. The national grid is composed of three distinct networks—the south interconnected network (RIS), the north interconnected network (RIN), and the east network (RE) (PPIAF, 2012). In 2012, the government embarked on diversification of the power generation mix so as to incorporate renewable sources such as solar and biomass in order to boost off-grid connection.

### *Cape Verde*

In 1999, the *Empresa Pública Electricidade e Água* (ELECTRA)<sup>32</sup> was privatized and the government sold 51% of the shares to a Portuguese consortium with a 50-year concession. The government retained 34% while the municipalities hold 15% of the share value. Initially, the consortium was not able to achieve commercial viability in balancing the low regulated tariff with increasing costs and it became insolvent in 2005, the power supply being plagued by extended blackouts.

In 2003 the government set up a regulatory authority - *Agência de Regulação Económica* (ARE)<sup>33</sup> - to regulate and assist the vertically integrated state-owned power utility. In 2006, the Cape Verde government re-acquired 51% of the share value of Electra and re-capitalized it. It currently holds an 85% share, with the local municipalities retaining the rest. In response to the utility's financial problems in 2004, the government sought assistance from the African Development Fund Electricity Transmission and Distribution Network Development Project to upgrade power distribution networks and to improve service quality. This enabled the country to achieve a relatively high rate of electrification, with about 66% of the population connected to the national grid (PPIAF, 2011).

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<sup>32</sup> Electra is Cape Verde's national power utility and supplies electricity to the nine inhabited islands of the country. It also operates as a water distribution utility in the four main islands.

<sup>33</sup> The Economic Regulation Agency is a multi-sectorial regulatory agency covering three sectors – Electricity, Water and Sanitation (PPIAF, 2011)

***Congo Democratic Republic/ (Congo-Kinshasa),***

The Congo Democratic Republic, a country rich in mineral resources, has also experienced years of ethnic conflicts, wars and mismanagement and this caused long-term underinvestment in electricity infrastructure development. The government of the Congo DR had an installed generation capacity of 2442 MW in 2006, of which only 1170 MW is available, thus resulting in just 15% of its population having access to electricity. The Societe Nationale d' électricité (SNEL), the state-owned sole provider of electricity in the country, controls all three core segments of the industry (i.e. generation, transmission and distribution) (AICD 2009).

In order to increase generation capacity, the government of Congo DR has signed an electricity trade agreement with neighbouring countries and is supporting capacity expansion projects. Inga 111, for example, is a project that is jointly owned by five southern African countries (Angola, Botswana, Congo DR, Namibia and South Africa) and is expected to increase regional generation capacity by 2000 MW (African Power Outlook, 2010).

The Congo DR has not attempted much in terms of power sector reform/restructuring, a part from an amendment of the electricity law in 2006 that allowed private sector participation in the sector, while the state-owned power utility company SNEL was converted into a Public Liability Corporation in 2010. As of 2014, EDC and Hydroforce are the only two independent private producers in operation in the power generation and distribution segments, contributing 5% in power generation and distribution. SAF Energy operates as an independent private transmission company in the transmission segment of the sector (Ministry of Energy, Congo DR, 2014).

***The Republic of Congo / (Congo-Brazzaville)***

Societe Nationale d'Electricite (SNE), the state-owned vertically integrated company, controls all aspects of power generation, transmission and distribution, but the rate of electricity consumption is low due to the limited transmission network that mainly serves the two most populous cities in the country (Brazzaville and Port Noire).

The country has made little progress in power sector reform following a decade of political instability and armed conflicts. These conflicts exacted a heavy toll on the country's power sector and, as a result, two-third of the populace (1997 -2000) were without power supply.

To improve the electricity situation in the country, the government embarked on power sector reform by amending the Electricity Law in 2003 to allow private sector participation. In the same year, SNE was converted from a public utility company to a commercial corporation. Moreover, while an independent regulatory authority was established (Agence de regulation du Secteur de l'Electricite - ARSEL), the Ministry of Energy, Mine and Hydro is responsible for formulating policies and issuing permits/licences to prospective investors.

The country has a generation capacity of around 511 MW as of 2013 which consists of the hydroelectric plants in Moukoulou and Djoué (which provide 74 MW and 15 MW respectively), the gas powered thermal plant in Brazzaville (32 MW), and the gas-fired plant at Pointe Noire has a capacity of 300 MW. The Imboulou hydroelectric power station currently produces 90 MW<sup>34</sup> (World Bank 2014).

The challenge faced by the Republic of Congo's power sector is that it still underdeveloped in terms of generation capacity, electricity access, and reliability of power supply. Though the country no longer depends on imports from the Democratic Republic of Congo, the power supply is still unreliable. Regular outages characterised the Congo republic power sector, which have forced both the firms and households to accumulate a stock of self-generation capacity of 207 MW. Also in term of access to electricity is well below the average when compared to other African peers in both urban and rural areas (Pushak and Briceno-Garmendia, 2011).

### ***Cote d'Ivoire (Ivory Coast)***

The power sector reforms in Cote d'Ivoire started in 1990 due to the financial state of the state-owned power utility, *Energie électrique de Cote d'Ivoire* (EECI). A French company - CIE (*the Compagnie Ivoirienne d'Electricite*) - were granted a 15-year concession for operation and management of power generation and distribution segments, while the government controls the transmission segment, as well as the import and export of electricity. The EECI was responsible for monitoring the implementation of the concession awarded to CIE (UNDP 2007).

The handover of the utility management to a private firm was successful in the sense that in the first year of operation CIE recorded a net profit of over US\$ 600 million (UNDP 2007). This provided a further incentive to the government to further deregulate the sector and, in

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<sup>34</sup> The Imbooulou hydro station was built with a capacity of 120MW.

1994, the Government chose to boost power generation to meet increasing demand by reducing its control over the sector. This saw more private independent power producers (IPPs) enter the sector such as CIPREL<sup>35</sup> (*the Compagnie Ivoirienne de Production d'Electricite*), which built and operates a 210 MW natural gas/open cycle power plant with a 19 year concession contract, and Azito<sup>36</sup> with a 288 MW natural gas/open cycle power plant with a 24 years concession contract (Eberhard and Gatwick, 2011).

In order to strengthen the institutional framework the government created the FNEE (*Fonds National de l'Energie Electrique*) to ensure financial support to the sector (UNDP 2007), and the second phase of restructuring was launched in 1998. This time, the government focus was on making the sector profitable, and this included the creation of three new state entities:

(i). ANARE (*the Autorite Nationale de Regulation du Secteur de l' Electricite*) was the regulatory authority with the responsibility to issue permits/licences to private firms that wish to invest in the power sector. ANARE formulates, coordinates and implements government policies in the power sector. It also has a responsibility to regulate the transmission, imports and export of electricity in the country.

(ii). SOGEPE (*the Societe de Gestion du patrimoine du Secteur de l'Electricite*) was responsible for marketing and attracting investors to the sector.

(iii). SOPIE (*the Societe operation Ivoirienne d'Electricite*) was in charge of the general operation of the entire sector (Eddy, 2005).

In 2011, the third phase of the restructuring was launched. The government merged SOGEPE and SOPIE to create a new electricity company named *Energies de Côte d'Ivoire* (CI-ENERGIES<sup>37</sup>) which focuses on planning, strategy development and investments in the sector (Amidou Traore, 2013). However, ANARE continues to act as a regulator with reinforced powers to ensure the protection of consumer interests and the settlement of disputes.

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<sup>35</sup> The Equity partners of the consortium are SAUR International with 88% (Joint Venture between French SAUR Group owned by Bouygues, 65% and EDF, 35%).

<sup>36</sup> The Equity partners of the consortium are Cinergy (Joint Venture between Swiss ABB, 50% and French EDF, 50%).

<sup>37</sup> On 21 December 2011, the Government approved decrees n°2011-470 and n°2011-471 merging SOGEPE and SOPIE.

***Egypt (Arab Republic)***

In March 1998, following amendment of the electricity law No. 18 (1996), the Egyptian Electricity Authority (EEA) separated distribution from generation; the distribution entities becoming seven vertically integrated subsidiaries that served geographic zones as local monopolies. The EEA continued to be responsible for transmission networks, dispatching, planning for a new generation and transmission projects, and the purchase of electricity produced by build, own, operate, and transfer (BOOT) projects. In 2000, the EEA was renamed the Egyptian Electricity Holding Company (EEHC) and was made responsible for the planning, development, and operation of the government-owned electric utilities.

In July 2001, the government deepened restructuring by unbundling the power system into thirteen companies (five generation, one transmission, and seven distribution). Each generation and distribution subsidiary was established as a separate corporate entity with its own board. This process of corporatization apparently reflected the government's intention that the EEHC should be expected to finance its own projects (Vagliasindi and Besant-Jones 2013). However in 2002, after the Egyptian government listed the seven distribution companies for offer on the Egyptian Stock Exchange, investors' lack of interest prevented the realization of this plan. Since then, the government has not shown any further interest in privatizing any of these entities. In the same year (2002), under electricity law number 164, the Egyptian government established a wholesale power pool in power generation. This enables the sector to coordinate generation and identify who is dispatching at specific times (each generator bids for dispatch and their generating units are scheduled to dispatch on the basis of these bids, the bids are based on costs). Due to the high growth rate of the power sector, the Egyptian government created two additional distribution companies in 2004. Thus, Egypt is currently served by nine electricity distribution companies, six generation companies, and one Transmission Company, all of which are affiliated to EEHC. Presently, while generation and distribution are under concession, EEHC manage and control the transmission segment.

Egypt faces a major challenge in providing sufficient electricity from its primary energy source (oil and natural gas), which currently contributes as much as 95% of the total energy resources needed for generating electricity in Egypt (IEA,2014). In early September 2014, the country experienced one of its most severe blackouts in a decade, which resulted in disruptions in the metro train service, and forced a number of businesses to shut down. In



response, the government are expanding the grid by incorporating renewable energy mixes in order to strengthen the system, with advances in smart grids, communications and technologies to support supply and distribution of generated power to the mass market (The National Business, March 2015).

### ***Ethiopia***

To cope with the increase in the demand for electricity supply as a result of the rapid rise in economic growth the Ethiopian government embarked on power sector reform. According to the Ethiopia Electric Power Corporation (EEPCO), the power sector is worth US\$ 3 to 4 billion per year. The long-term plan is to maximise the country's power potential, which is currently believed to be 45,000MW hydropower, 10,000 MW geothermal and 1.03 million MW wind power (EEPCO, 2015). The power sector reform process may be classified into two phases.

The ***first phase*** consisted of the issuance of the 1994 Energy Policy and promulgation of Investment Proclamation No. 37/1996, the enactment of Electricity Proclamation No. 86/1997 (Electricity Proclamation), and the establishment of the Ethiopian Electric Power Corporation (EEPCO) in July 1997 which was corporatized under regulation 18/1997 to run the electricity trading business on commercial principles. In 1998, the government established an independent regulatory agency (Ethiopia Energy Authority) to regulate the activities of the Ethiopian Electric Power Corporation (EEPCO). The objective of EEA was “*to promote the development of efficient, reliable, high quality and economical electricity services*”. The formation of the Electricity Operations Council (Ministers Regulation No. 49/1999) in May 1999 culminated the first phase of the reform.

The ***second phase*** of the reform process was launched by the enactment of Energy Proclamation No. 810/2013 (Energy Proclamation) on November 19, 2013, and proclaimed in the official *Negarit Gazeta* on January 27, 2014. As part of this second phase of the reform process, EEPCO has been unbundled into two separate entities, (the Ethiopian Electric Power (EEP) and the Ethiopian Electric Utility companies (EEU)<sup>38</sup>. EEP was established to undertake electrical power generation, transmission construction and operation while EEU undertakes electricity distribution, network construction and operation, and purchases bulk electrical power to sell to consumers. EEU is managed by the Indian Power Grid Company

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<sup>38</sup> Through Council of Ministers Regulation No. 302/2013 and No. 303/2013 (EEP Regulation and EEU Regulation) respectively, enacted on December 27, 2013

on a two-and-a-half-year management contract signed on December 17<sup>th</sup>, 2013. Both EEP and EEU are government owned enterprises accountable to the Ministry of Water, Irrigation, and Ministry of Energy as directed by Public Enterprises Proclamation No. 25/2014.

### ***Gabon***

Hydroelectric dominates power generation and accounts for 76% of Gabon's power production<sup>39</sup>. The state-owned vertically integrated power utility - ***the Société d'Electricité et d'Eaux du Gabon*** (SEEG) – had a monopoly over generation, transmission and the distribution of electricity and the distribution and supply of water (UNDP 2012). In 1997, it sold a 51% share in SEEG to a French consortium owned by Vivendi. Electricity prices have fallen since that time, largely because Vivendi has improved the country's generating capacity and reduced the transmission and distribution losses to 19%. The remaining shares of SEEG are owned by SEEG employees (5%) and the public (44%) (UNDP 2012).

SEEG supplies electricity to the cities of Libreville, Port Gentil and the inland city of Franceville. A current investment venture proposes improving the quality of supply and extending electricity to other areas of the country (Gabon National Infrastructure Master Plan 2012). In 2010, the government established a multi-sectorial regulatory authority *Agence de Regulation du Secteur de l'eau Potable et de l'énergie électrique* (ARSEE) to regulate activities in energy and water service.

### ***Ghana***

Ghana is a country with a semi-liberalised electricity industry which is dominated by three state-owned vertically integrated utilities namely the Volta River Authority (VRA), the Ghana Grid Company (GridCo), and the Electricity Company of Ghana (ECG) while independent power producers (IPPs) have a marginal share in the industry. The VRA was established by an Act of Parliament in 1961 (the Volta River Development Act, 1961 (No.46)) with primary responsibility for generation and part responsibility for distribution of electricity in the northern part of the country<sup>40</sup>. GridCo is responsible for transmission and system operations whereas the ECG is responsible for the distribution of electricity in other parts of the country.

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<sup>39</sup> The power generating dams in Gabon are Tchimbele (69 MW), and Kinguele (58 MW) on the M'Bei River, and Poubara on the Ogooue River. Other electricity generating stations are powered by gas-fired thermal plants (210 MW) and a heavy-fuel power station (30 MW).

<sup>40</sup> In the mid-1980s, as a result of extension of the national grid, Brong Ahafo, Northern, Upper East, Upper West and the Ashanti regions were added to VRA coverage (Hunt 2002).

In 1997, the government of Ghana accepted a final white paper and recommendations to restructure the Ghanaian power sector. Reform in the sector was seen as necessary due to frequent power failure, unreliable power supply, over billing by the state-owned utility corporation and a lack of sufficient funds to invest in new power stations. Within the same year, the government of Ghana established two independent regulatory agencies (Public Utilities Regulatory Commission (PURC)<sup>41</sup> and Energy Commission (EC)<sup>42</sup> charged with the responsibility to formulate energy policies, create a suitable environment for investment and the regulation of electricity tariffs. In 1999, VRA entered a joint venture agreement with the USA based firm (CMS Energy) to generate 220MW (Kapika and Eberhard 2013).

However, the reform did not fully commence until 2000, when the first independent power provider - Takoradi International Company (TICO) entered the industry. Despite this, the progress of the reform was slow until 2008 when the Volta River Authority (VRA) was unbundled and generation separated from transmission, though the VRA also retained its national distributor status (Kapika and Eberhard 2013). Although the reform of the Ghana electricity market is on-going the expectation was that liberalization of the sector would increase the inflow of foreign investment to the sector. To date, it has fallen short in this regard.

### ***Kenya***

The Kenya power sector reform occurred in two phases. The first phase commenced with the enactment of the Electric Power Act 1997. The priority was to ensure an efficient power sector that would be able to provide a reliable power supply and to meet the demand of the populace. To this effect, the KPLC (Kenya Power and Lighting Company) assets were divided among two successor companies. The KPLC retains the assets for transmission and distribution, while the Kenya Electricity Generating Company (KenGen) was placed in charge of most of the electricity generation assets (The Point, 2003). Under this arrangement, all the electricity generated must be directed to the KPLC for transmission and supply to

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<sup>41</sup> PURC is loosely referred to as the 'economic regulator', and is primarily responsible for tariff setting, performance monitoring, promotion of competition and complaints handling, it also regulates water resources.

<sup>42</sup> The EC is referred to as the 'technical regulator', and is responsible for licensing, technical standards and performance monitoring. It also renders policy advice on the energy sector to the Minister. The EC is also responsible for the petroleum and gas sector (Kapika and Eberhard 2013).

national consumers. Similarly, in the same year (1997) the Electricity Regulatory Board (ERB) was established to perform regulatory oversight over the sector<sup>43</sup>.

Under the first phase, there was an increase in installed generation capacity from 870 MW to 1,162 MW, although only 1051 MW was operational in 2003 (The Point, 2003; and UNDP 2007).

In 2006, another Act, the Energy Act 2006 was passed. The main features of the 2006 Act were the renaming of the Electricity Regulatory Board (ERB) into the Energy Regulatory Commission (ERC)<sup>44</sup>, the setting up of a Rural Electrification Authority, expanding the number of network service providers, and creating an Energy Tribunal to settle conflicts and disputes. The Act of 2006 commenced the second phase of the restructuring in the sector, and saw the government sell 30% of its stake in the Kenya Electricity Generating Company (KenGen). In the same year the government formed two additional companies because of the poor financial condition of KenGen, as the law prevented financially fragile companies from raising large amounts of capital in the stock market. The two companies are Kenya Electricity Transmission Company Limited to operate in parallel with the Kenya Power and Lighting Company (KPLC)<sup>45</sup>, and the Geothermal Development Company (GDC) which was established to exploit the huge untapped geothermal energy potential in the country

Furthermore in 2010, in an effort to meet the increased demand for power the government embarked on a diversification of the power generation mix. There was also an increase in the number of private power producers in the sector, from two IPPs in 1995 to over fifteen IPPs in 2010. Typical examples were the geothermal plant (Olkaria III at 48MW) and a diesel-fired thermal plant, Kipevu II (at 74MW)<sup>46</sup> (Kenya Power, 2014).

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<sup>43</sup> The ERB is charged with the responsibility to oversee the formulation, coordination and implementation of energy policy in the industry, and also the setting of electric tariffs, the issuing of licence permits to private sector investors, and to coordinate tenders.

<sup>44</sup> The ERC's mandate extends beyond the power sector and includes natural gas, renewables and all other forms of energy.

<sup>45</sup> The laws regulating the financial market in Kenya requires the government to inject new capital into any listed company, it can do so only by buying additional number of shares, either in a rights issue or increased issued shares. Thus the most direct effect of such a move would be to alter the shareholding structure and, in the case of KenGen (from a 70:30 percent share structure, any such changes would most likely see KenGen run afoul of the Capital Market Authority rules on continuous listing obligation, which require any listed company to have at least 25 percent of its issued shares held by the public ("State's Big Return in Power Business" *Daily Nation*, July 27, 2009).

<sup>46</sup> Olkaria III, developed by OrPower4, began commercial operation in 2000. Similarly Kipevu, developed by Tsavo commenced operation in 2001.

To a large extent, Kenya's power sector has experienced some positive impacts as a result of the reform, with the generation segment unbundled also as a result of the public sale of shares in KenGen. The entry of IPPs has increased the installed capacity under private ownership from 16% in 2001 to 46% in 2013, although the transmission and distribution sectors are still bundled. However, despite all these achievements, the increase in the cost of electricity in Kenya is a hindrance to both expansion of electricity supply in the rural areas, and to meet the demand from industrial (especially mines) and residential households in the urban area.

### ***Madagascar***

Madagascar is endowed with abundant energy sources but historically did not have the necessary means to exploit them. Madagascar's energy balance shows that about 80% of its overall energy consumption is based on biomass (mainly firewood 68%, charcoal 10% and other biomass 2%), 17% on petrol (transport), and just 2% on electricity (hydropower and diesel power plants) and 1% on coal (Ffooks and Glass, 2014). Electricity and water services are provided by the vertically integrated state-owned power utility - *Jiro sy Rano Malagasy* (JIRAMA) which operates and controls all the three key segments of the industry – (i.e. generation, transmission and distribution). In 1999, the JIRAMA monopoly was broken as the government sought to open the sector up for private sector participation through the award of concessions or permits to the private sectors. In 2003, the government established an independent electricity regulator, *the Office de Régulation de l'électricité* (ORE), with the responsibility for granting permits/licences and concessions to private suppliers from Madagascar and abroad (Ffooks and Glass, 2014).

The challenges facing the sector are the high electricity price (which has risen by 13% on power consumption exceeding 230kWh, with local reports citing a further increase of 25% in prices possible), and frequent power cuts- which are largely attributed to over-dependence on hydroelectric dams. The government is considering building a nuclear plant and developing renewable sources of energy, mainly wind and solar energy. In order to encourage the development of renewable energy, the government has exempted related equipment from incurring customs fees and Value Added Tax. The Government Finances Law of 2013 also allocates 25.7% of the public investment programme (*PIP*) to the sector to promote energy use, especially that of renewable energy (Ffooks and Glass, 2014).

## ***Malawi***

Malawi power sector generation is dominated by hydropower plants, though thermal (diesel and gas-fired plants) and small photovoltaic systems are also in use. The total installed capacity of ESCOM (the Electricity Supply Corporation of Malawi Limited) is about 302 megawatts, of which 94% is generated by hydropower and the remaining 6% is thermal. Almost all the major existing hydropower plants in Malawi are located in the Southern region of Malawi along the Shire River (the main outlet of Lake Malawi)<sup>47</sup>, except for 4.5 MW which is located in the Northern region on Wovwe river, Malawi's biggest river. A significant number of industrial enterprises in the country have their own installed diesel and petrol operated generators due to the unreliable power supply from the state-owned power utility. Electrical power is transmitted to all other parts of the country through 132 kV network grids with 66 kV being used in some areas. Overall, the electricity network of the country is not in very good shape, resulting in substantial losses in the transmission and distribution networks of about 18% - 22% of the generated electrical energy (ESCOM, 2013).

The Electricity Supply Corporation of Malawi (ESCOM) was converted into a limited liability company in 1998 under the Companies Act of 1984. In 2004, a new legal framework for the sector was passed, comprising the Energy Regulation Act, Electricity Act, and Rural Electricity Act. In 2007 a new independent regulator was created: the Malawi Energy Regulatory Authority (MERA (Mloza-Amiri, 2005 and Gamula, 2013). Overall, Malawi has implemented 60% of identified best-practice institutional reforms<sup>48</sup> for the power sector, which puts it ahead of the average score for Sub-Saharan Africa. In spite of the reform, there is no current private sector participation in the country's power sector<sup>49</sup>.

However, the Malawi power sector has suffered considerably from unreliable power supplies because a majority of her hydro generators are old and their operation is affected by droughts, floating aquatic weeds/plants and debris being transported in the rivers (ESCOM, 2013).

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<sup>47</sup> Power stations in Malawi are Tedzani I and II - 40 megawatts (1977); Nkula A 120 megawatts (1981); Wovwe - 4.5 megawatts (1995); Nkula B - 24 megawatts (1996); Tedzani III - 50.

<sup>48</sup> Best practice reforms refer to processes whereby knowledge concerning policies, administrative arrangements, or institutional structures across states, sectors and periods are explicitly utilised to inform decision making (Stone, 2001).

<sup>49</sup> Private sector participation in the power sector in Malawi remains a challenge due to the government subsidy provided to ESCOM, which gives an unfair advantage to ESCOM over any competitors who might invest in the sector. Hence ESCOM has remained the sole company in charge of the three segments (generation, transmission and distribution).

## **Mali**

In 1994, the Malian government attempted to privatize the state-owned power utility company *Energie du Mali* (EDM) due to the Company's high levels of debt, but after resistance from labour unions and protests from the general public, it was abandoned. Instead, in an effort to improve the Company's financial and operating performance, a management contract was awarded in 1995 to *Société d'Aménagement Urbain et Rural* (SAUR) a French-Canadian consortium made up of Hydro-Québec (Canada) and Électricité de France (EDF). However the management contract was terminated in March 1998 after relationships between the foreign managers and the Malian board of directors deteriorated (Clark et al. 2005 and UNEP, 2007). EDM has since undergone three phases of reform. The first phase saw the transfer of the decision-making power to a foreign firm/professional partner to manage the affairs of the corporation. The next phase saw the setting up of a mixed investment company management system, a stage which prepared the company for privatization, and the last stage saw the privatization of the national utility company in March 2000 (UNEP, 2007).

In 2000, the Malian government signed a 20-year concession contract with SAUR/IPS-West Africa who acquired 60% of EDM, with the government retaining ownership of the other 40%. Regulatory bodies were established – the Electricity and Water Regulatory Commission (CREE) and the Agency for the Development of Household Energy and Rural Electrification (AMADER). AMADER is responsible for off-grid energy service and generation systems below 250kw, while the CREE provides assistance for the general development of the sector, controls tenders and grant concessions, and approves tariffs. However in 2005, SAUR decided to pull out of the concession agreement with the government and handed its shares back to the government in October. Thereafter the Malian government entered into a partnership with the Aga Khan Group, with 66% of the shareholding held by the government and 34% by the Aga Khan Group (UNEP, 2007).

This arrangement seems to have been effective as, according to World Bank Enterprise surveys, the share of firms relying on their own generator fell from 45 percent in 2003 to just over 23 percent in 2007, and the share of power consumption supplied through own generation fell by half to 16 percent over the same period. Transmission and distribution

losses due to power outages were less than 2 percent of sales, which is among the lowest on the continent (Briceno-Garmendia et al. 2011).

However, EDM still depends on the government subsidy to be functional and the institutional framework of EDM continues to be a challenge, as EDM currently manages both electricity and water services (Briceno-Garmendia et al. 2011).

### ***Mauritius***

The Central Electricity Board (CEB), a state-owned power company controls transmission, and distribution, and generates 60% of all the electricity used, with the remaining 40% being purchased from sugar estates (independent power producers). The Mauritius transmission grid is based on a network of 66 kV lines, which form a ring around the island linking the main demand centres, with some cross-links. The average electricity costs are relatively high; reflecting the fact most power generation is based on imported fossil fuel. The power sector in Mauritius has undergone restructuring during the last few years, moving from a state of almost complete dependence on fossil fuel for electricity generation to a position whereby most of the electricity is generated from coal and bagasse (Deepchand, 2005).

The government, through the CEB, sought to improve electricity supply in the country by establishing an integrated Electricity Plan (IEP) 2002–2012 to provide a reliable, affordable and sustainable electricity supply for Mauritius and Rodrigues. The major milestones of this plan included expanding electricity generation capacity from 237 MW to 664 MW, commissioning 6.3 MW engines, upgrading of electricity network, and a scaling up of renewable energy - with a targeted 4.8 MW increase in production (Mutanga, 2014).

The second Integrated Electricity Plan of 2012 - 2022 seeks to build on these accomplishments by optimising the use of the existing power system to keep the cost of electricity low, to encourage demand-side management, and to provide continued private-sector opportunities in the energy sector. The plan expects peak electricity demand will increase to 574 MW under the base case scenario and 702 MW under the high-case scenario, implying an annual increase of 14.4 MW over the period 2013–2022 (Mutanga, 2014). The challenge facing the Mauritian power sector, like that for many African and developing economies, is to attain an effective energy mix that can boost power generation and satisfy demand.



## **Morocco**

Morocco is the only North African country with no own oil resources, but the largest energy importer in the region. The country is faced with the challenging task of meeting the rising demand for electricity while keeping its import bill under control. Against this backdrop, Morocco embarked on restructuring her power sector.

The electricity market in Morocco is dominated by the government controlled operator ONEE (*Office National de l'Electricité et de l'Eau Potable*). ONEE owns and manages the transmission network, the distribution network is operated as a concession, while independent power producers are active in power generation (although ONEE acts as the single buyer in the sector). The power distribution concession involves seven local municipal utilities, also known as “Régies” (utilities for distribution of electricity and water owned by a municipality, group of neighbouring communes), as well as four private distribution utilities, also known as “gestionnaires délégués” (Ameground, 2015).

Morocco's effort to restructure its power sector and reposition it to be competitive and sustainable was encouraged by the World Bank. In 1994, the government of Morocco adopted a decree which allowed the national power monopoly ONEE to enter into power purchase agreements with Independent Power Producers (World Bank, 1994). In 1996, ONEE awarded CMS Energy and ABB Energy 30-year concession agreements under a competitive bid tender. The agreement consisted of two elements. The first was to manage two currently operating 348-MW coal-fired/steam-based generation units under a 30-year concession arrangement. The second consisted of power plant expansion and the building of two similar specification generators under a build-transfer-operation (BTO) arrangement (Ameground, 2015).

In 2006 the first combined cycle power plant, a joint venture between ONE, Siemens and Endesa, was commissioned (World Bank, 2007). In 2008, the Moroccan government decided to further open the power generation market to private investors. Private power producers were allowed to own and operate plants with capacities not exceeding 50MW, and sell their electricity directly to large industrial consumers. In 2010, a new Renewable Energy Law was passed which set a new legislative framework for the promotion of renewable investments and established a procedure for the authorisation of renewable energy installations (as well as production, distribution and trade) in the country. This created a new market in which certain

industrial customers are allowed to freely choose their electricity suppliers (Brand and Zingerle 2010).

However, the power sector still faces financial difficulties including: (i) a tariff structure that does not reflect the sector's operating costs; (ii) the low collection (payments) rate and difficulties in recovering debts from certain distributors and the public sector; (iii) the excessive use of expensive heavy fuel oil and diesel in energy production as a consequence of delays in investments in large cost-effective generation facilities; and (iv) the growing burden of debt service (ESMAP 2011).

### ***Mozambique***

Mozambique is rich in energy resources and endowed with hydropower potential but the devastating effects of the civil war, which lasted for a decade and a half<sup>50</sup>, left the country's infrastructure in a poor condition and chronically underdeveloped. The need for restructuring in the power sector of the country was paramount as there were no direct transmission lines from the Cahora Bassa hydroelectric dam to the capital city Maputo or other southern regions of the country. In 1997, the government of Mozambique accepted a World Bank report on reform and regulation of its power sector and the National Energy Strategy Act was passed in 2000, establishing a single-buyer model. The state-owned vertically integrated utility corporation the *Electricidade de Mozambique* (EDM) is the dominant player in the industry.

In 2001 the power generation segment was unbundled, Transmission remained regulated by the government, while private sector participation in the form of IPP and leases/concession contracts was permitted for distribution networks (NVE 2004). Thus, with the support from the World Bank, Mozambique was able to implement an eight year energy reform and access programme (ERAP), with the objective of expanding the transmission network, attracting foreign investors and improving the quality of life of the populace in the rural and pre-urban areas in the country (Mahumane and Nadand, 2012). In 2008, the electricity regulatory authority was established (*the Conselho Nacional de Electricidade - CNELEC*), although the Ministry of Energy is in charge of the implementation of projects, coordinating electrification investment and rural electrification. The state-owned utility company (EDM) now focuses on the transmission and distribution networks, while Hydroelectric Cohora Bassa (HCB), the hydroelectric company jointly owned by Portugal and Mozambique, operates and manages

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<sup>50</sup> The Mozambique civil war started two years after independence from Portugal. The war broke out on 30<sup>th</sup> May, 1977 and ended on 4<sup>th</sup> October 1992.

hydropower activities. HCB generates up to 85% of the total generation capacity of the country while the IPP and other fuel-powered generators generate 15% (ACID, 2009).

### *Namibia*

The challenge faced by Namibia's power sector is the volume of electricity that it imports. Declining in power supply from the Southern African Power Pool has exposed the country to high degree of uncertainty in relation to future supply as Namibia has been unable to enter into long-term contracts with its major supplier, Eskom and lack the capacity to be independent.

In 1996, Namibia's first experiences of private participation in the power sector occurred when Northern Electricity began to operate the distribution system in the north of the country under a concession agreement. The industry regulator, the Electricity Control Board (ECB) was established in 2000, with Namibia's Ministry of Mines and Energy responsible for energy policy formulation and direction, and the ECB mandated to regulate the energy sector. The sector is dominated by the state-owned and vertically integrated **NamPower**, which owns and operates most of the country's generation and transmission assets, as well as some distribution facilities in the rural areas of central and southern Namibia. The majority of the distribution of the power supply is undertaken by the City of Windhoek (the country's largest distributor), while the rest is managed by two regional electricity distribution companies (REDs) – the Northern RED (Nored) which covers most of the northern part of the country stretching to the Caprivi Strip, and the Erongo RED (Erongored), which covers the central coastal region to the west of the country including Walvis Bay and Swakopmund – and by numerous small municipal distribution operations (Kapika and Eberhard, 2010).

Under the new management, Northern Electricity Company, experienced improvement in terms of collection bills, reduction electricity theft rate, increase in power-system reliability and the connection rate improved. Despite these significant positive attributes, and the liberalisation of the sector in 2000, private-sector participation in the industry is virtually zero. The country's flagship Kudu gas-to-power project is facing ongoing delays and the expectation that independent power producers (IPPs) would form an important part of achieving indigenous generation continues to be unfulfilled. The ECB has made good progress, but more work remains if the security of electricity supply is to be obtained (Kapika and Eberhard, 2010).

## *Nigeria*

In 2005, the government of Nigeria enacted legislation (the Electric Power Sector Reform Act) in order to create a clear regulatory framework that encourages more competitive markets and, at the same time, attracted private investors and ensured the economically sound development of the system. The Act was designed to reposition the power sector from a government controlled, heavily subsidized system to a privatized, largely market-based, industry. Subsequently, in 2005, the government of Nigeria changed the name of the utility from the National Electricity Power Authority (NEPA) to the Power Holding Company of Nigeria (PHCN) and established an independent regulatory authority the Nigerian Electricity Regulatory Commission (NERC) to regulate the sector and issue operating licences.

In 2007, the government unbundled the sector by creating 18 successor companies – 6 GENCOs<sup>51</sup>, 11 DISCOs<sup>52</sup> and 1 TCN<sup>53</sup>. In addition, the NERC has licensed about 70 Independent Power Producers and 10 National Integrated Power projects (NIPPs) in the country (KPMG, 2013). Implementing the 2005 Reform Act has been challenging for the Nigerian government and progress stalled between 2007 to 2009. However, the process was revitalized in 2010 with the establishment of the Presidential Task Force on Power (PTFP) and a roadmap for power sector reform was published in August 2010 (KPMG, 2013, PWC, 2013).

Having established the framework and institutions for power sector reform, the reform process was completed in 2013 with the handing-over of the power stations (Gencos and Discos) to the successful bidder companies and the signing of an agreement with a Canadian firm - Monitola Hydro International (MHL) to manage the Transmission Company of Nigeria<sup>54</sup>. There are high expectations that the present reform will not only improve

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<sup>51</sup> Afam Power Plc, Egbin Power Plc, Kainji/Jebba Hydro Electric Plc, Sapele Power Plc, Shiroro Hydro Electric Plc and Ughelli Power Plc.

<sup>52</sup> The eleven electricity distribution companies in Nigeria are: Abuja Distribution Company, Benin Distribution Company, Eko Distribution Company, Enugu Distribution Company, Ibadan Distribution Company, Ikeja Distribution Company, Jos Distribution Company, Kaduna Distribution Company, Kano Distribution Company, Port Harcourt Distribution Company and Yola Distribution Company.

<sup>53</sup> The Transmission Company of Nigeria.

<sup>54</sup> Manitoba won the contract to manage operations of TCN in July 2012 at a price of \$23.7 million for three years. The contract requires that MHI take over the staffing and management of key departments of TCN (such as the Systems Operations, Transmission Service Provider, National Control Centre, Information Technology and Market Operations).

electricity supply but also aid energy diversification and development in Nigeria (PWC, 2013).

### ***Rwanda***

Rwanda is trying to bridge its widening energy deficit, which is putting pressure on its economy. With an installed capacity of 120 MW, the challenge faced by the Rwanda power sector is high, with power outages (an average of 14 blackouts per month), high energy prices and shortfalls in revenue collection. The cost of energy has risen to \$0.22 per kilowatt-hour (KWh), compared with \$0.08 to \$0.10 in the rest of the East African region (World Bank 2013). However, connectivity to the national grid remains relatively low, at 15 percent of households.

Restructuring of the power sector in Rwanda started in 2001 when the Rwanda Electricity Corporation (RECO) was created and it assumed all of Electrogaz's electricity-related activities, assets, and liabilities. A regulatory authority was also established, known as the Rwanda Utilities Regulatory Agency (RURA), with the responsibility to regulate both the power and gas sectors. The Electricity Law of 2008 split the state-owned power utility company RECO into separate electricity and water parastatals. The two separate water and electricity successor utilities (RWASCO and RECO) were re-integrated in 2010 as the Energy, Water and Sanitation Authority (EWSA).

In 2014, EWSA was split into two different bodies again. The Water and Sanitation Corporation Ltd is in charge of ensuring the supply of clean water, while the Rwanda Energy Group is responsible for electricity. The latter is subdivided into the Energy Development Company Ltd (which is in charge of energy generation and network expansion), and the Energy Utility Company Ltd (for supply and distribution of electricity).

In support of power sector reform, the Rwandan government has approved a number of legal, regulatory, and private-sector development initiatives. The government expects an additional 65.5MW to be generated after the completion of ongoing projects, which include Nyabarongo I MHPP (28MW), Kivuwatt -Gas (25MW), Giciye MHPP (4 MW), and the IPP Solar PV power plant. The government has set a national target to increase the country's electricity access to 70 per cent by 2017, which includes a plan to increase installed capacity to 1,160MW by 2017 (AfDB, 2104).

## *Senegal*

Not until 1998 were major power sector reforms undertaken in Senegal. Senegal's power sector was split into three entities: **Senelec** (the national utility), the Agency for Rural Electrification (*Agence Sénégalaise d'Électrification Rurale*, ASER), and the Electricity Regulatory Board (*Commission de Régulation au Secteur de l'Électricité*, CRSE). While electricity generation, mainly on a Build-Own-Operate (BOO) basis, is open to the private sector, Senelec (the sole buyer) signs power purchase contracts with independent power producers (Niang, 2006, Niang, 2011, Ngom, 2009, Sari, 2009).

In 1999, the government made an attempt to privatize SENELEC (*Société nationale d'électricité du Sénégal*) but failed<sup>55</sup>. A second attempt was made in 2001 (after a new government came into power), but this too was unsuccessful (Gökgür and Jones, 2006).

In 2003, the government adopted a new strategy reflecting the lessons learned over the 1999-2002 period. It aimed at expanding and improving the reliability of SENELEC's generation, transmission and distribution system, and high priority was placed on mobilizing private resources for generation expansion under IPP arrangements (World Bank, 2013). Due to poor market design and poor implementation of the new strategy, it did not yield the expected outcomes, in spite of the assistance provided by the World Bank and bilateral donors in the form of budgetary support. Instead, SENELEC ended up in crisis<sup>56</sup> and the country witnessed recurrent blackouts with un-served demand reaching 105GWh in 2008 (World Bank 2013 and Mawhood and Gross 2014).

The Senegalese power reform has not achieved its key objective and disagreements within the Government, have contributed to the cancelling of plans for new short-term capacity additions and significant delays in the negotiation of IPP arrangements (World Bank 2013 and Mawhood and Gross, 2014).

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<sup>55</sup>This was due to disagreements between the private partners and the Government on issues related to investment plans and tariffs (UNDP, 2007).

<sup>56</sup> Senegal's electricity sector is caught in a downward spiral caused by the poor state of SENELEC's finances and the sector's under-investment. SENELEC's under-capitalization and structural operating deficit (caused by low tariffs and lagging budgetary transfers) perpetuates inefficiency by preventing it from investing in the required maintenance of aging assets and non-liquid fuel-based generating plants, which could improve its cost structure in the long-run while improving the quality of service (World Bank, 2013).

### *South Africa*

The South African power sector has always been dominated by the state-owned and vertically integrated utility (Eskom). It enjoys a near monopoly in both generation and transmission segments, accounting for about 96% of the country's total installed generating capacity and 95% of generated electricity<sup>57</sup>. It also controls virtually 100% of the transmission assets, although in the distribution segment Eskom's dominance is less pronounced as it shares the sector with municipal distributors. It still controls 45% of distribution networks, with the remaining 55% provided by 188 local authorities (Eskom Annual report, 2012).

South Africa is a member of the Southern African Power Pool (SAPP), a regional body of different national electricity utility companies, organised under the auspices of the Southern African development community. It is the only member that has achieved self-sufficiency in electricity production. Although Eskom imports power from some SAPP member countries such as the Democratic Republic of Congo and Zambia, it is mainly for peak load management, and is also contractually bound to take electricity from a hydro plant in Mozambique. However, at the same time, Eskom sells electricity to the neighbouring countries of Botswana, Lesotho, Mozambique, Namibia, Swaziland, Zambia and Zimbabwe (ESKOM, 2012).

However, following the change of government in South Africa in 1994, the need to reform Eskom was a top priority in the government agenda. In 1995 the National Electricity Regulator was established with the legal mandate to issue permits/licences to prospective electricity suppliers, to approve their tariffs, to monitor the quality of supply, and to settle disputes.

In 1998, the government approved a white paper on energy policy which emphasized the need to increase private sector participation in the sector and to promote efficiency through competition. In line with the vision of the policy, Eskom was converted into a public liability company through the Eskom Conversion Act of 2001

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<sup>57</sup> Although Eskom does not have exclusive generation rights, it has a practical monopoly on bulk electricity. It also operates the integrated national high-voltage transmission system, and supplies electricity directly to large consumers such as mines, mineral resources producers and other large industries. In addition, it supplies electricity directly to commercial farmers and, through the Integrated National Electrification Programme (INEP), to a large number of residential consumers. It also sells in bulk to municipalities, which distribute to consumers within their boundaries (NERSA, 2015).

In 2004, the government set a target of a 30 percent increase in generation capacity from the private sector in order to create competition, but the target was not met. In 2006, the Department of Energy and Mineral Resources unsuccessfully sought to procure two gas turbine power plants to complement generation during peak loads.

Since 2008, there has been a decline in the generation capacity of Eskom and this has put Eskom under significant pressure to boost generation capacity and provide a stable supply of power. The National Energy Act, (No. 34) of 2008, put into effect a number of proposals from the White Paper on Energy Policy that had thus far not been addressed. For instance, while the white paper indicated that reform should ultimately result in customers having a choice of supplier, little progress had been made (Newbery 2009). In 2010, the Integrated Resource Plan 2010 (IRP 2010) and the Policy-Adjusted IRP set out a 20-year electricity plan (2010–2030) for South Africa to increase capacity and change the nation's energy mix.

Despite the limited reform to date in South Africa, some achievements have been seen. For instance, access to electricity supply has improved with 3.5 million new households connected to the national grid between 1994 and 2001. In 2010, access to electricity was 82.7% and in 2012 it has increased to 85.4% of the population (World Bank Development Indicators, 2014).

### *Tanzania*

Over the past two decades, the power sector in Tanzania faced enormous challenges including capacity shortages, mismanagement, low investment and poor maintenance of aging plants, coupled with an increase in electricity demand. Hence, it was vital for the government of Tanzania to restructure and reposition the sector to be productive, efficient, and attract more private investment in line with the country's economic policy (Vision 2025).

In 2002, the government amended the Electricity Law and approved an arrangement to contract the management of TANESCO (the Tanzania Electricity Supply Company Limited) to NETGroup Solutions Ltd of South Africa<sup>58</sup>. In the same year the first independent power producer (Independent Tanzania Power Limited (IPTL)) was incorporated into the power generation segment, and in 2004, another private producer Songas was added to the system. Both IPTL and Songas produced power and fed it into the national grid<sup>59</sup> (Ghanadan and

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<sup>58</sup> The initial arrangement was for two years, later extended to another two and half years in 2004.

<sup>59</sup> Songas produces 190 MW using natural gas and IPTL produces 100 MW using heavy fuel oil.



Eberhard 2007). Apart from IPTL and SONGAS there are other smaller private producers (Aggreco, Symbion Power LLC), with Aggreco and Symbion (emergency power plants<sup>60</sup>), and Wentworth Resources<sup>61</sup> (Tanzania Ministry of Energy and Minerals, 2011).

In 2005, legislation was passed to form a Rural Energy Agency and Rural Energy Fund (REA/REF), which pursues non-commercial rural electrification initiatives and started functioning in 2007. The Energy and Water Utilities Regulatory Authority (EWURA) was approved in 2006 and became operational the same year, with the task to ensure regulatory oversight to promote sector investment (Tanzania Ministry of Energy and Minerals 2014).

Tanzania's reform outcomes were mixed. The early years of the management contract with NETGroup was successful as revenue collection of TANESCO increased, although the contract was subsequently terminated. Operational efficiency improved and the number of customer connections to the national grid increased<sup>62</sup>. However, the average price of electricity gradually also went up, from 6.2 US cents/kWh in 1993 to 10.7 US cents/kWh in 1996 and had increased by 12.69% in 2013 (Eskom, 2015), as the government cut the electricity tariff subsidy from 100 kWh in 2003 to 50 kWh in 2012 (Kapika and Eberhard, 2013). Installed capacity has more than doubled (from 482 MW in 1992 to 1564.1 MW in 2012), and there is also an improved energy mix which has reduced the overdependence on hydropower<sup>63</sup>.

Despite these achievements, there are still challenges such as; the high commercial and technical losses, the low level of revenue collection, the use of expensive thermal power in power generation and, during the dry season, water level decreases cause most of the hydropower plants to shut down (TANESCO Financial Report, 2014).

### ***Tunisia***

Prior to the 1980s, access to electricity was low as only 6% of the rural population were connected to the power grid. In the 1990s, the figure had increased to 54%, due to the growing economy and rising living standards and this led to a significant increase in

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<sup>60</sup> Emergency power plants started operating in December 2010, after Tanzania experienced a heavy drought which reduced power generation capacity from 561 MW to 120 MW.

<sup>61</sup> Wentworth Resources, formally known as Artumas Limited, operates in the Islands and it is engaged in generation, transmission and distribution.

<sup>62</sup> For instance the customer-to-employee ratio was improved from 67 in 2001 to 97 in 2003 and the number of customers increased from 450,947 in 2001 to 530,000 in 2004, and in 2013 is 1,200,000.

<sup>63</sup> Prior to the reform, most power generation stations in Tanzania were hydro (about 80% in the 1990s), the remaining 20% were diesel generators. In 2012 the mixture is 35% hydro, 61% thermal, and 4% renewable energy.

electricity demand and consumption, resulting in the saturation of the grid (REEEP, 2014). In addition, some power plants and facilities were too antiquated. As a consequence, overload losses and high voltage drops occurred on a frequent basis. To address these issues in 1996 the government embarked on a restructuring of the *Société Tunisienne de l'Électricité et du Gaz* (STEG), the state-owned vertically integrated utility company. While STEG had a monopoly over power generation, transmission and distribution, the Electricity Law of 1996<sup>64</sup> opened the way for independent power producers to enter the power generation segment on condition that STEG<sup>65</sup> remained the single buyer of the power produced (STEG Annual report, 2013).

In 2002, Tunisia's first independent power producer (IPP) – the Carthage Power Company was completed and became operational. A second IPP, a 13.5 MW associated gas plant began producing in 2003, operated by the *Société d'Électricité d'El Bibane* (SEEB). The liberalization of the power sector has helped to expand electricity access significantly, from 54% in the 1990s to 99% of the population in 2013. Tunisia subsequently created a legislative framework for the implementation of a national energy and renewable energies development programme (*Loi n° 2009-7* and Implementation decree No. 2009-2773 of 28th September 2009), which opens up various investment and development opportunities to private operators.

As of 2014, the total installed capacity of Tunisian power generating system is 4,799MW, of which STEG owns and operates 86%, the remaining 14% are operated by IPPs (Bureau of Statistics, Ministry of Industry, Tunis). However, Tunisia's energy mix largely dominated by fossil fuels, a large percentage of which are imported. These fossil fuels produce more than 98.8% of the electricity generated in the country, leaving only a tiny percentage of electricity produced from renewable energy. To promote and support the diversification of energy sources and increase the percentage of electricity produced from renewable energy sources STEG has created a subsidiary dedicated to renewable energies (STEG Annual Report, 2014).

Despite the success of the reforms, the Tunisian power sector faces a big challenge as electricity supply is heavily subsidised. The average retail prices is 0.14 TND/kWh in 2012,

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<sup>64</sup> Law N° 96-27, dated 01/04/1996, authorised the State-owned power utility to grant electricity generation licences to independent producers with a view to its exclusive sale to STEG.

<sup>65</sup> The conditions of the power purchase agreement (PPA) are partially defined in the call for tender of the concession contract and in part subject to the final negotiations between the concessionaire and STEG (Bureau of Statistics, Ministry of Industry, Tunis).

which is significantly lower than average production costs (0.26 TND/kWh in 2012). In 2012, energy subsidies amounted to 5,600 million TND (3,100 million EUR), 20% of the public budget, and 9% of GDP (STEG Annual Report, 2014).

### *Uganda*

In the late 1980s the Ugandan Government embarked on an Economic Recovery Programme (ERP) with support from the World Bank and the IMF as the economy was immersed in economic crises and suffered political instability. Electricity production had fallen from 150MW in 1963 to 60MW in 1995 (Kuteesa et al. 2010).

Prior to reform, the Ugandan power sector was dominated by a state-owned, vertically Integrated Uganda Electricity Board (UEB). In 1997 the government initiated a power sector reform aimed at unbundling the sector, enhancing the quality of service, improving on connectivity and reliability, reducing losses and attracting capital from the private sector (Mawejje et al., 2012).

In 1999 Parliament enacted new electricity legislation, mandating the government to liberalise the power sector, establish new institutions and seek private sector participation. The legislation also provided for the establishment of an autonomous regulatory body to regulate the electricity industry and a Rural Electrification Trust Fund (RETF) to provide electricity supply to the rural area. The regulator, the Electricity Regulatory Authority (ERA), became operational in 2000.

In 2001 the Uganda Electricity Board (UEB) was unbundled into three separate companies namely: The Uganda Electricity Generation Company Ltd; The Uganda Electricity Transmission Company Ltd; and The Uganda Electricity Distribution Company Ltd (UEDCL). The concession for the generation segment was signed in 2002 and started operation the same year. In 2004 the electricity distribution segment was converted into a private firm (UMEME), being managed and operated under a 20-year concession agreement (Mawejje et al, 2012).

As a result, of the reform, there has been an increase in investment in power generation, with the 250 MW Bujagali Hydroelectric Power Station constructed as a public-private project at a

cost of approximately US\$862 million (ERA, 2013)<sup>66</sup>. In October 2013, the construction of the 183 MW Isimba Power Station<sup>67</sup> commenced and is scheduled to be completed in 2018. Work also commenced in 2013, on the construction of the 600 MW Karuma Power Station, and completion is expected in December 2018.

As of 2014 there are six operational mini-hydropower plants connected to the national grid supplying 65 MW: Nyagak I (3.5 MW), Kabalega (9 MW), Kanungu (6.6 MW), Bugoye (13 MW), Mubuku I (5 MW), Mubuku III (10 MW), and Mpanga (18 MW). In addition, there are two thermal power stations: Namanve Power Station is a 50 MW plant<sup>68</sup>, and Tororo Power Station a 70 MW thermal power station. There are also five sugar manufacturers in Uganda that have a total cogeneration capacity of 110 megawatts, of which about 50% is available for sale to the national grid<sup>69</sup> (The East Africa, 2015 and ERA, 2014). In 2014, ERA licensed two solar power stations, each with the capacity to generate 10 megawatts.

### **Zambia**

Zambia had a total installed generating capacity of 2,177 megawatts (MW)<sup>70</sup> in 2014. The power supply is dominated by the state-owned vertically integrated company, the Zambia Electricity Supply Corporation (ZESCO). There are two other important participants: the Copperbelt Energy Corporation (CEC), a private sector firm that purchases bulk power from ZESCO and supplies the copper mines and neighbouring communities, and the Lusemfwya Hydro Electricity Company that operates a 40 MW power station (the only independent power producer in the industry connected to ZESCO's transmission network), which provides electricity to the Kabulu Manganese mine and to ZESCO (Vagliasindi and Besant-Jones, 2013).

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<sup>66</sup> The consortium that owns the hydro power station includes: - the Aga Khan Fund for Economic Development, Sithe Global Power LLC (a subsidiary of the Blackstone Group), and the government of Uganda. Bujagali Energy Limited run the station on behalf of the shareholders.

<sup>67</sup> The station is 40 kilometres from Bujagali, and it will cost approximately US\$590 million. It is a public enterprise venture with funding from the Export-Import Bank of China (Daily Monitor, March 2015).

<sup>68</sup> Owned by Jacobsen Electricity Company (Uganda) Limited, a subsidiary of Jacobsen Elektro, a Norwegian-based power production company, built in 2008.

<sup>69</sup> These are the Kakira Power Station (52 MW), the Kinyara Power Station (40 MW), the Lugazi Power Station (14 MW), the Kaliro Power Station (12 MW) and the Mayuge Power Station (1.6 MW).

<sup>70</sup> There are seven power stations: Kafue Gorge (990 MW), Kariba North Bank (1080 MW), Victoria Falls (108 MW), Lusemfwya and Mulungushi (56 MW), Small Hydro combined (25 MW), Isolated generation (8 MW) AND Gas Turbine (80 MW).

The low access to electricity and the poor financial condition of ZESCO led the government to embark on a reform of the power sector in 1995. An electricity law was passed mandating the government to restructure the power sector and establish new institutions to oversee the activities of the sector. In 1997, the Energy Regulation Board (ERB) was established (ERB, 2000).

In 2001, the government sought to break the monopoly of ZESCO. It sold 51% of its shares in the Mulungushi and Lunsemfwa power stations to Eskom (a South African company), 29% to a local investor (Dagarnier) and 20% to Wand Gorge Investment. In 2003, ZESCO was partially privatized, as the government rejects full privatization in favour of divestiture (IMF and IDA, 2005).

In order to provide electricity for rural dwellers, the Rural Electrification Authority (REA) was established by the Act of Parliament No. 20 of 2003. The government also embarked on a strategy to diversify energy mix in power generation, as Zambia's increasing reliance on hydropower was affected sharply during drought<sup>71</sup>. Although Zambia is endowed with renewable energy resources (solar, the wind and geothermal) that can be exploited for both on-grid and off-grid systems, efforts to date to harness these resources have been minimal. National electrification has increased from 20% in 2000 to 48 % in 2012 (IRENA, 2013) while ZESCO'S consumers have expressed dissatisfaction with the poor quality of the electricity supply (ERB, 2014).

### ***Zimbabwe***

Prior to 1985 Zambia and Zimbabwe had a joint electricity system with CAPCO (the Central African Power Corporation) producing hydroelectricity on behalf of the two countries. ZESA (the Zimbabwe Electricity Supply Authority) was established in 1985, a vertically integrated monopoly responsible for generation, transmission and distribution. It is the sole exporter and importer of electricity in the country and the sole supplier of electricity to the public grids. In 1996 subsidiaries of ZESA were formed; the energy generating company the Zimbabwe Power Company (ZPC) and the Zimbabwe Electricity Transmission and Distribution Company (ZETDC).

In 2001, the Rural Electrification Fund (REF) Act was passed into law. The REF is responsible for grid extension in rural areas and for supplying specific institutions, such as

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<sup>71</sup> Zambia witnessed droughts in 2005, 2008 and from mid-2014 to 2015

schools, clinics, government offices, and community-initiated projects. REF covers the cost of its operation through levies on electricity and petroleum sales and from the financial support it receives from the government and donors. Although access to electricity grew from 27% to 34% between 1996 and 1999, and from 36.9% to 40.4% between 2010 and 2012, the rate of progress is slow (World Bank, 2014).

In accordance with government policy to embark on reforms of the power sector, a new Electricity Act was enacted in 2002 leading to the restructuring of the Zimbabwe Electricity Supply Authority (ZESA). The vertically integrated utility was converted into separate successor companies (under ZESA Holdings), with the Zimbabwe Power Company (ZPC), is responsible for all generating stations and for the supply of power to the transmission grid, the Zimbabwe Electricity Transmission Company (ZETCO), the Zimbabwe Electricity Distribution Company (ZEDC), and POWERTEL. Powertel is primarily responsible for providing communication services to the power companies (MOEPD, 2004). In addition, the Act also provided for the setting up of an autonomous regulatory body that would oversee private investment in the power sector through appropriate regulatory, fiscal and environmental frameworks.

In 2005, the Zimbabwe Electricity Regulatory Commission (ZERC) was established to strengthen the institutional oversight of the sector, with the expectation that private investors would be attracted into the sector.

In 2010, ZETCO and ZEDC were merged into a single company to save cost, and ZETDC (Zimbabwe Electricity Transmission and Distribution Company) is now responsible for transmitting and distributing electric power, billing, revenue collection and meter reading (MOEPD, 2013).

Historically the Zimbabwe power sector had suffered from unsustainable operation owing to financial constraints as a result of inefficiencies in revenue collection, illegal connection and vandalism of distribution lines. Since 2012 the government has embarked on a programme to add new generating capacity and to rehabilitate old power stations so as to improve the power deficit, but its impact is still to be seen (Bloomberg, July 2015).

### 3.10 Conclusion

As we have seen in this chapter, many developed and developing countries have embarked on different types of power sector reforms over the past three decades. These reforms have taken place against a backdrop of a wider pattern, a shift from state ownership and vertically integrated organization to public-private ownership and market-oriented structures (OECD, 2000). The new approach to the power sector reflects a general dissatisfaction with the performance of traditional models of state-owned enterprise and the desire to improve the efficiency and enhance the productivity growth of this sector. Moreover, success recorded by pioneering countries (Chile, Great Britain and Norway), have contributed to the adoption of reforms in other countries (*see section 2.2*).

The driving forces behind electricity market reforms in developed and developing countries seem similar but are different. Thus, in developed countries, the primary aim of reforms has been to improve the performance of relatively efficient systems, while in developing countries, the burden of financial constraints, price subsidies, low quality of service, low revenue collection rates, high transmission and distribution network losses, low access to electricity and underinvestment have meant that many governments are no longer willing (or able) to support the existing arrangements (Jamash, 2006; Newbery, 2002; and Joskow, 1998). In addition, international development agencies (World Bank and other International donor agencies) have provided support and/or promoted the implementation of power sector reforms especially in developing countries. This market-oriented reform came with some conditionality attached. Our study shows the experience of some of the countries across Latin America, Asia and African countries. One common policy lesson that cut across all the developing countries reviewed is that many of the countries lack some of the institutional and structure framework necessary to embark on a full implementation of the standard reform program.

Secondly, electricity tariff reform continues to be a main challenge facing policymakers in developing countries. The problem of cost recovery, underpricing and subsidy continue to affect the industry (Kessides, 2012b).

The policy lesson from Latin American countries, according to McKenzie & Mookherjee (2005); Gviria (2006); Nagayama (2007); and Balza et al. (2013), is that majority of the countries in the region tend not to follow the reform sequence as introduced by the World Bank. For instance; Chile and Colombia privatised their power sector without introducing

unbundling (Fischer et al. 2003 and Nagayama, 2007; Pombo and Tabora, 2006). Similarly, in India some state privatised and introduced unbundling (Bhatia and Gulati, 2004), but did not establish a regulatory body nor introduced competition.

As this chapter has shown, power sector reforms in Africa have taken place within diverse political, economic, and structural contexts. Many of the reforms were initiated as a condition from the World Bank for developing countries to securing loans and aid to combat economic crises. Consequently, power sector reforms have taken a variety of forms and paths (Bacon and Besant-Jones, 2001; Millan et al., 2001). Given this background, it is perhaps not surprising that many reforming countries have encountered unexpected problems and have only achieved, to some extent, their goals (Jamash, 2006).

The African experience with power sector reform has shown that implementing and sustaining workable restructuring, competition, and regulation is more complicated than initially anticipated. For instance, in both Malawi and Namibia, in spite of the reforms, not a single independent power producer has invested in the country (Mloza-Amir, 2005; UNDP, 2007; and Kapika and Eberhard, 2013).

Electricity systems in Africa vary significantly in size, structure, and generation mix and this complicates comparison and the transfer of experience. In addition, many reforming countries lack the necessary regulatory framework, experience, and skilled human resources. Furthermore, in most countries, reforms are constrained by weak institutions. In the case of Senegal for example, three attempts were made to privatize the national utility company without success, due to the poor institutional framework, poor market design and poor implementation strategy. In Tanzania, while the management contract with the NET Group saw the firm record success in revenue collection, improve efficiency and increase the number of customers connected to the national grid, the contract with NET Group was unceremoniously terminated before the due time (Kapika and Eberhard, 2013).

Electricity market reform in developing countries must follow a logical sequence, as it is costly to undertake market-oriented reform in the wrong order. It is a combination of both institutional and structural reforms (i.e. vertical and horizontal restructuring of the industry).

First, the reforming country must restructure its tariff structure, setting tariffs a little above (or equal to) the total expenditure of the operators and completely removing any form of subsidy in the industry.



Secondly, the establishment of a regulatory body and (especially the application of incentive-based regulatory mechanisms), the total privatization of the industry. Third, it is necessary to introduce competition and separate the different segments of the industry into independent entities (*In chapter four, we refer to it as government commitment*) can lead to significant improvement in the performance of the electricity market in developing countries.

However, most of the developing countries lack some of the essential ingredients and other pre-conditions for full implementation of the standard reform model, as outlined by main donors such as the World Bank. A majority of these countries have evolved or evolving into hybrid forms (i.e. partial reform of electricity reform).

Lastly, market-oriented reforms in electricity markets that incorporated the local conditions will be successful and leads to improved efficiency and enhanced the productivity of the sector, increase private sector participation and offer a better quality of service (*i.e. a combination of various reform variables lead to significant improvement*) (Besant-Jones, 2006). At the same time, flawed reform design and ineffective policy can undermine the benefits of reforms.

The next chapter, the first empirical study in this thesis, examines to what extent do liberalization policies (in the form of regulation, privatization, introducing competition and unbundling) influence performance in the power generation sector. We test our hypotheses on power generation using four performance indicators (total electricity generation, installed capacity, labour productivity and generation capacity utilization) in the sector as dependent variables.

## Chapter 4

### **To what extent does liberalisation policy impact on electricity generation? A panel study of African countries power sector performance.**

#### **4.1 Introduction**

One of the greatest challenges facing African countries in the 21<sup>st</sup> century is to achieve a reliable/sustainable power supply to enable her to cope with an increasing population and urban growth. In a bid to stimulate growth/development, and rise above the economic, social, political, and environmental crises that have beset the region over the last four decades, the governments of various countries of the region (together with the support of multilateral institutions) have introduced market-oriented economic reforms. Among these reforms are those aimed at improving the technical, financial, managerial and operational efficiency of the power utilities. These reforms come in the form of facilitating divestiture, offering management contracts, privatisation, granting concessions (with a view to guaranteeing future electricity supply in an open globalised energy market), and allowing independent power producers (IPPs) to invest in the electricity generation sector. The power industry in Africa, as we have shown in the previous chapter, was mainly characterised by chronic power outages, unreliable power supply, mismanagement of resources, low capacity utilisation and a high cost of production, deficient maintenance, poor procurement of spare parts, and high transmission and distribution losses.

A reliable power supply is needed both to industrialize and to provide basic energy for the populace living off the grid in urban and rural areas in different countries of the region. Multilateral institutions such as the World Bank, African Development Bank, Inter- America Development Bank and other subsidiaries of World Bank (who are the main sponsors/donors of this programme) have stipulated the kind of reform programmes countries in the African region should adopt. It can take different forms, for instance: Electricity law amendments (which often involves a country's national law making bodies amending an existing act/law and passing it into law); Corporatization, sometimes referred to as commercialisation (the act of transforming a government-owned utility into a limited liability corporate body); Restructuring the power sector (to allow private participation in the generation sub-sector – Independent power producers (IPP)); and the utility can be unbundled (that is breaking it up

into different components – generation, transmission and distribution). Sometimes, it can involve the privatisation of the different components of the electricity supply industry (either wholly or partially) although in the case of the African countries it is largely the latter. Another option is to create an autonomous/independent regulatory agency, rather than allowing direct regulation by government ministry/parasternal (AICD 2008).

The type of market reform that is implemented depends on what is perceived as the country's needs, for example: In the case of Ghana, electricity demand is outstripping supply, resulting in overloaded network grids coupled with obsolete plants which make power delivery very difficult. The load on the generation and distribution grid has grown at about 10 percent a year, but there had not been adequate investment and expansion of the electricity power generation infrastructure to match the growth in demand (Kusi 2005). In 1997, the Ghanaian Parliament passed two laws, (i) the Public Utilities Regulatory Commission (PURC) Act 538, and (ii) the Energy Commission (EC) Act 541, which established the legal and regulatory framework for electricity supply industry reforms. In 1998 the electricity corporation of Ghana was commercialized, becoming the Electricity Company of Ghana plc (ECG). Later the government of Ghana decided to partially unbundle the electricity power industry, and the distribution grid was assigned to the Volta River Authority (VRA)<sup>72</sup>, which has a subsidiary called the Northern Electricity Department (NED) which supplies power to the northern region of Ghana.

This chapter proceeds as follows. The next section provides the motivation for our research and what the study aims to address. Section 4 develops the methodological framework, details the data set and provides the model specification. Section 5 states the research hypotheses. Section 6 presents the empirical model, results and analyses, the following section presents the empirical discussion and the last section concludes.

#### **4.1.1 What Does This Study Address?**

It is generally acknowledged in economic theory that unreliable power supply results in welfare losses (Kessides 1993). However, previous empirical studies in this field focus on the experiences of Europe, North America, South Asia and the Latin American regions, with few studies on the performance of the African electricity generation sector. One exception was

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<sup>72</sup> The Volta River Authority (VRA) is the state-owned power generation and transmission company. The VRA owns and operates the 1020 MW Akosombo hydropower plant and 160MW hydro generating station in Kpong.

Foster and Steinbuks (2009) who analysed the consequence of unreliable power supplies in Sub-Saharan Africa using data from the UDI World Electric Power Plants Data Base (WEPP), and the World Bank's Enterprise Survey Database. Their study focused on the contribution of in-house generation of electricity by private firms in sub-Saharan Africa. Their findings suggest in-house electricity generation would remain a prevalent part of the system in Africa, even if power supply increases, the reason being that firms see it as an emergency back-up.

Zhang et al. (2008) examined the effect of three reform indicators (privatization, competition, and regulation) on the general electricity sector reform process in 36 developing countries. Using the Asia Pacific Energy Research Centre (APEREC) database, World Development Indicators, and the Industrial Statistics Yearbook, they constructed a panel (unbalanced) dataset and found insufficient evidence that reform variables on their own impacted on electricity sector performance (with the exception of competition).

However, Zhang et al.'s (2008) estimation overlooked an important reform variable – vertical unbundling<sup>73</sup>. Also, only six African countries<sup>74</sup> were included in the study. Second, the study was based on a general model, instead of a more specified interaction effect model (that is, allowing for more interaction effects among the reform variables). It is important to note that the cost of electricity generation constitutes the main factors that determines the final electricity prices. However, we made attempt to include this variable in our research, as it has been ignored so far in almost all cross-country econometric panel studies on the impact of market-oriented reforms in the electricity supply industry [See Erdogdu (2011), Nagayama (2007 and 2009), Zhang et al. (2008), Fiorio et al. (2007), Hattori & Tsutsui (2004) and Steiner (2001)]. Hence our study will incorporate this variable into our analysis, making an important contribution to the existing literature.

This study combines the advantage of cross-country and panel (balanced) data analysis to examine how certain reforms - specifically structural and institutional changes - have influenced the performance of electricity generation sector in African countries. To do this,

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<sup>73</sup> Vertical unbundling is a key indicator in the power sector reform process. It helps to reduce the degree of concentration in the generation and distribution segment of the sector and also is a source of attracting additional investment from both the private and public sectors (Vagliasindi and Besant-Jones 2013).

<sup>74</sup> The six countries included in Zhang et al. (2008) are Algeria, Kenya, Morocco, South Africa, Tanzania and Zambia

we employ a panel data set from 30 African countries in the region with yearly aggregated data over a period of 24 years (1989 -2012).

This chapter will seek to address and provide answers to the following questions: First, does liberalizing the electricity generation sector in developing countries increase electricity generation, promote efficiency, increase productivity and enhance capacity utilisation? (i.e. do market-oriented policies in the form of privatization, regulation, competition and unbundling have an impact on the performance of the power generation sector)?

Second, does economic reform in the form of market liberalization in the electricity supply industry lead to more installed generation capacity (and hence output growth)?

Thus, our specific objectives are:

To estimate to what extent do reform policies affect power generation performance.

To determine the impact of major countries on power generation trends in the region.

To evaluate the status of electricity restructuring in the region and to offer suggestions on the way forward.

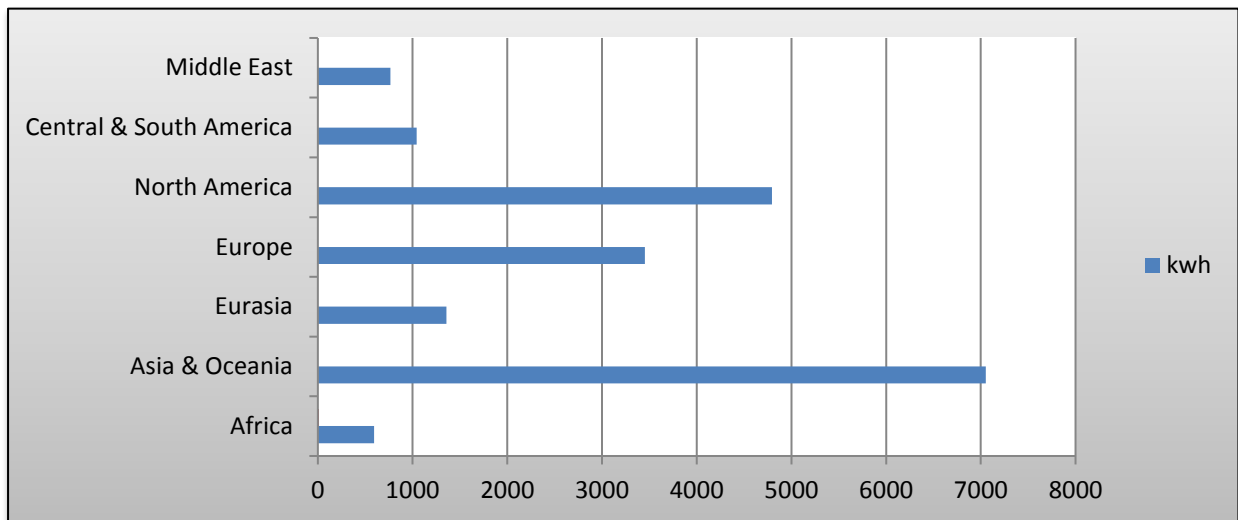
This chapter does not investigate the effect of reform on household/industrial access to electricity, the quality of service and price, as the next chapters will treat these particular aspect. Our aim in this chapter is to examine to what extent do reform elements – such as privatization, competition, unbundling and regulation - enhance electric power generation in African countries.

## **4.2 Overview of Power Generation Challenges in Africa.**

Africa's power supply industry is facing many challenges, mainly due to an undeveloped power market (insufficient generation capacity) which has limited electricity supply, resulting in low access and service quality. The main obstacle to an increase in electricity generation capacity is the high cost of producing electricity and the government's subsidy for consumption. In 2010, the average effective electricity tariff in Africa was US \$0.14 per kilowatt-hour (kWh) against an average of US \$0.18 per kWh in production costs. Consumption is effectively subsidized, but with significant disparities among African countries. For example, while electricity tariffs in South Africa and Zambia are among the

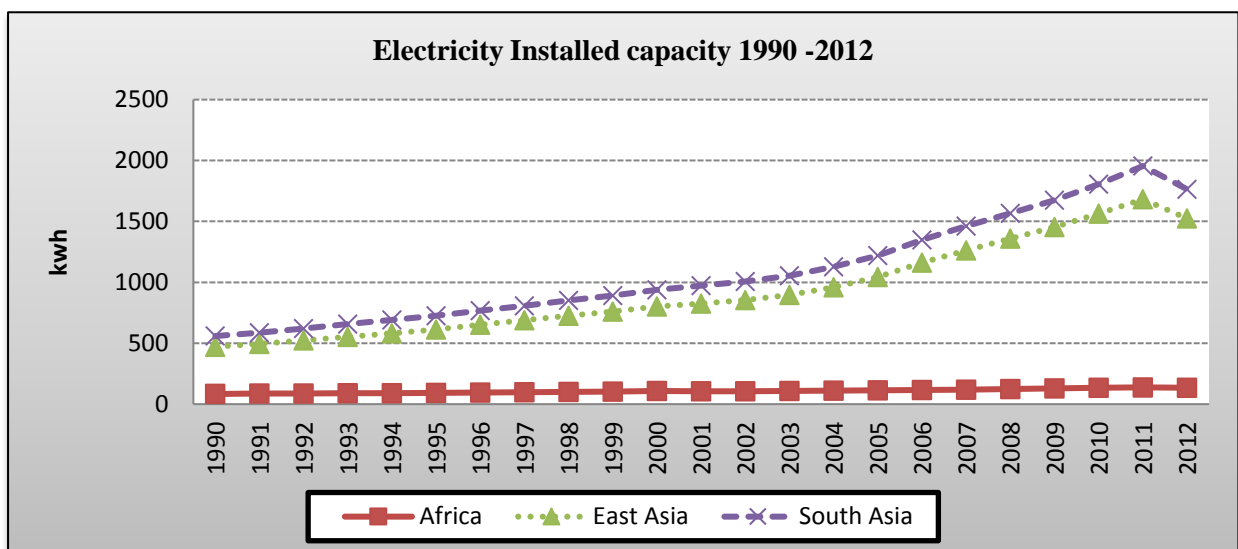
lowest in the world, prices in Djibouti and Gabon are among the highest globally, due to a reliance on diesel – based power - generation (ADB 2013).

For the past three decades, the region has lagged behind other regions of the world in power generation and installed generation capacity, (see Figure 4.1).



**Figure 4.1:** Total Electricity net Generation (billion kilowatt-hours) in 2012  
 Source: Compiled by author from EIA (2012), and World Bank (2012).

The average installed capacity in Africa in the 1980s and early 1990s was about the same as in the south Asian region but currently is lower than in any other developing region (AICD 2008). Also, the cost of electricity generation is higher in the African region when compared to other regions of the world.



**Figure 4.2:** Electricity Installed capacities (million kilowatts)  
 Source: Compiled by author from EIA, (2012), and World Bank (2012)

The low level of power generation is attributed to the correspondingly low installed capacities and lack of investment in electricity network expansion in the region, especially in Sub-Saharan Africa. The progress recorded to date in the African region (excluding South Africa and the North African countries) is slow in this regard. As Table 4.1 below shows, between 2000 to 2012 East Asia added at least 10 percent in power generation, South Asia added at least 50 percent, while the African region recorded only 7 percent growth (EIA 2012).

**Table 4.1:** Developing Regions Installed Generation (million kilowatts) 1990-2012

Developing Regions	Total Installed Capacity (1990 -1999)	Average	Total Installed Capacity (2000 -2012)	Average
Africa	924.52	92.45	1555.26	119.64
East Asia	5138.58	513.86	14043.62	1080.28
South Asia	1093.92	109.39	2546.38	195.88
Middle East	830.34	83.03	2065.49	158.88
East Europe & Eurasia	4164.87	416.49	6049.92	465.39
South East Asia	640.58	64.06	1725.52	132.73
South America	1353.29	135.33	2613.09	201.01
Total	16145.79	1614.58	30587.37	2352.87

**Source:** Source: Compiled by author from (EIA, 2012, and World Bank 2012)

### 4.3 Studies on the restructuring of Power Sector

There is a large literature that has examined the impact of liberalization policies on the electricity supply industry. The category of studies includes country specific, cross-country and comparative analysis comparing power generation. Some of these studies adopted a descriptive approach which merely reports the reform outcomes on power generation (World Energy Council 2002). Examples are Bacon (1995), Czamanski (1999) and Besant-Jones (2001), who describe and explain the principal driving forces behind developing countries power sector reform. Jamasb et al. (2005) used the concept of ‘push’ and ‘pull’ factors to explain the different rationale between developed and developing countries power sector reform. “Push” refers to unfavourable macroeconomic conditions that give rise to reform, while the latter relates to the incentives associated with power sector reforms. For example, Mawejje (2012) assesses the impact of liberalisation policy on Uganda’s power generation sub-sector. The study made use of descriptive data analysis methods augmented by empirical estimations of ordinary least square dummy variable models to estimate if the reforms are on track to meet its intended objectives. The results suggest that progress has been slow. However, other studies have carried out econometric empirical testing of the effect of liberalization/deregulation policies in the power generation sub-sector.

#### 4.4 The Econometric approach to Power generation reform

Before market-oriented reform was introduced in the electricity generation sector in the African region, the electricity power industry was made up of vertically integrated state-owned utilities. Previous studies (Joskow 2008, Jamasb et al. 2005) have argued that state-owned utilities are characterized by low productivity, with prices lower than costs, leading to severe difficulties in access to power in rural areas.

Khanna and Zilberman (2001) analysed the contribution of regulatory and technical factors to power generation efficiency in India. They use data from 1988 to 1991 for sixty-three coal-based power generators (plants). They measured efficiency by the amount of heat required to produce a net kWh of electricity and by electricity consumption. Their results suggest that energy efficiency was lower at plants operated by state-owned power utilities than at private plants (holding constant factors such as power generator age and capacity utilisation). Secondly, they find that improving state management practices leads to higher performance and can match those efficiency rates seen in the private sector.

Shanmugam and Kulshreshtha (2005) made use of a stochastic frontier production model (SFP) to examine the technical efficiency of fifty-six coal-based electricity power generators in India for the period 1994 to 2001. They estimated whether technical efficiency parameters changed during the period of their analysis. Their results suggest that technical efficiency levels did not vary much during this period; however they point out that there was variation in technical efficiency across the power generators. They estimated technical efficiency on plant age and region dummies, and their result shows there is a decrease in efficiency with age and efficiency is lower for plants located in the northern part of the country.

Cubbin and Stern (2006) use data for 28 developing countries over the period 1980-2001 to determine whether the existence of a regulatory law and quality regulatory governance are significantly associated with high power generation performance. Their empirical results suggest that holding other relevant variables constant and allowing for country-specific fixed effects, a regulatory law, and higher quality governance is positively and significantly associated with higher per capita generation capacity levels and higher generation capacity utilisation rates. However, it is worth noting that the reform needs at least three years to have a positive impact.



Zhang, Yin-Fang et al. (2008) examine the restructuring of regulation and privatisation in the electricity utility industry in both developed and developing countries. They used an econometric approach to assessing the effect of privatisation, competition and regulation on the performance of the electricity generation industry using panel data for 36 developing and transitional countries over the period 1985–2003. The findings generated from the models suggest impact of the reforms variables on electricity installed capacity, net electricity generation, labour productivity and capacity utilization. In contrast, individually this reform variables do not have any impact on the electricity generation performance indicators, rather when there co-exist (interaction effect).

Du, Limin et al. (2009) reviewed China's experience of regulatory reforms in its electricity supply industry, with the central planning system broken up and a market-oriented reform introduced into the Chinese power sector. In addition, the former vertically integrated electricity utilities were divested and the generation sector was separated from the transmission and distribution networks. They assess the impact of regulatory reforms on generation efficiency of fossil-fired power plants using plant-level national survey data from 1995 to 2004. An econometric method of Differences-in-Differences<sup>75</sup> was used to estimate the effects of restructuring on the demand for inputs of employees, fuel and nonfuel materials. Their results suggest that the net efficiency improvement in labour input associated with the regulatory reforms is roughly 29 percent and the gains in nonfuel materials are about 35 percent. However, there is no evidence of efficiency gains in fuel input associated with the electricity reforms. Sen and Jamasb (2010) use panel data for the period 1990-2007 to estimate ex-post power generation efficiency gains from Indian states. They examined the impact of electricity reforms on plant load factor (PLF), total generation, transmission and distribution losses. They find that the unbundling and tariff order variables are significant and have a strong positive effect on plant load factor (PLF), as does the ratio of industrial to agricultural electricity prices. Their results suggest that the Electricity Regulatory

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<sup>75</sup> Difference - in- difference refers to an outcome(s) observed for two groups in two time periods. For instance, if the first group is exposed to a treatment in the second period but not in the first period. Then the second group is not exposed to the treatment during either period. In the case where the same units within a group are observed in each time period (panel data), the average gain in the second (control) group is subtracted from the average gain in the first (treatment) group. This removes biases in second period comparisons between the treatment and control group that could be the result from permanent differences between those groups, as well as biases from comparisons over time in the 2 treatment groups.

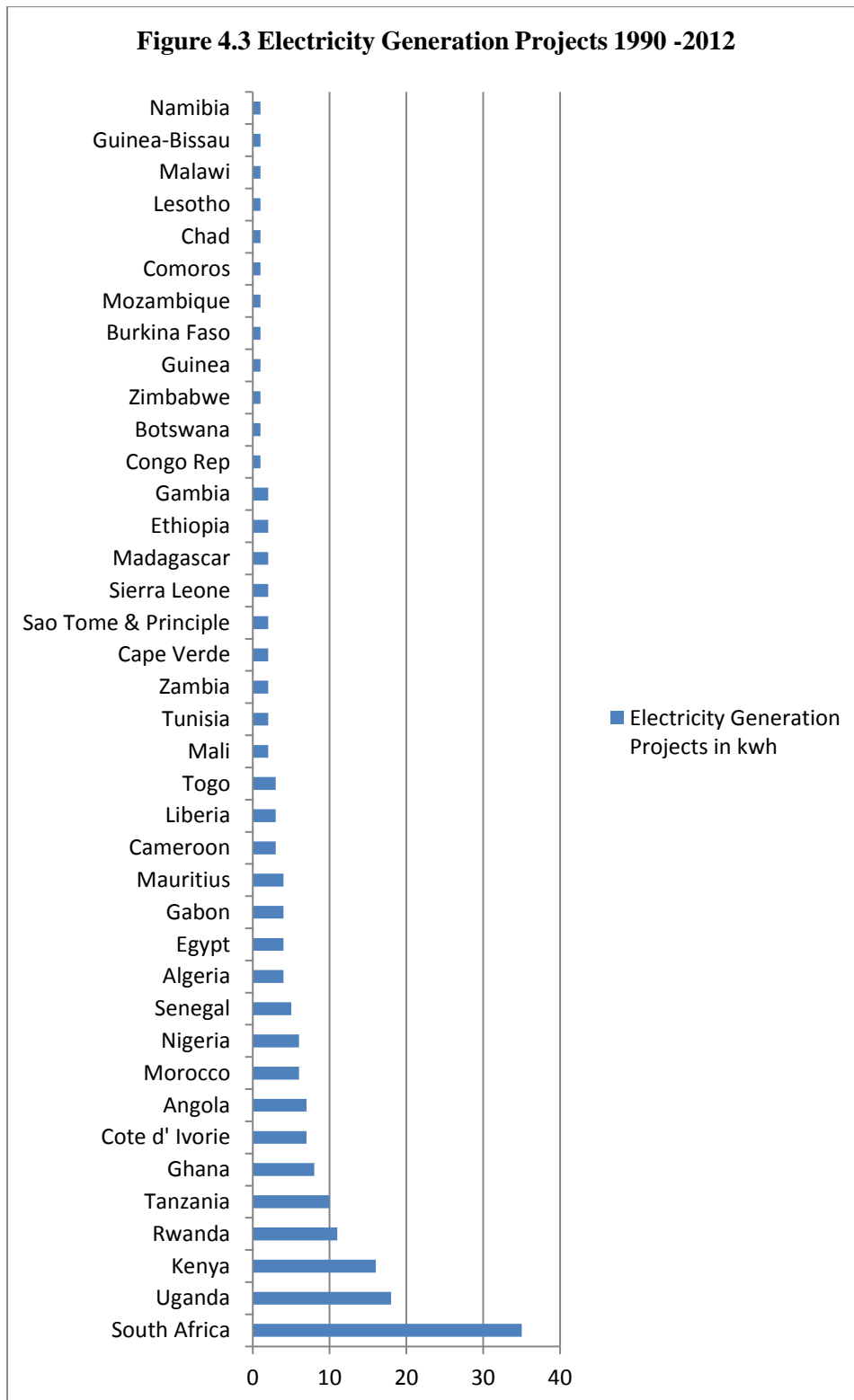
Commission (SERC), unbundling and privatisation dummies have increased transmission and distribution losses, possibly due to the reduced ability to hide existing losses after reform.

However, an alternative to the state-level approach employed by Sen and Jamasb (2010) saw Cropper et al. (2011) use data from 1994 -2008 to measure the impact of unbundling on the operating efficiency of the state-owned thermal power generators in India. They take advantage of differences across states in the timing of reforms to examine the impact of reform policy on plant generator performance. Their results suggest that unbundling leads to significantly improved plant generating performance of about 4.6 percent and a 2.9 percent reduction in the number of power outages.

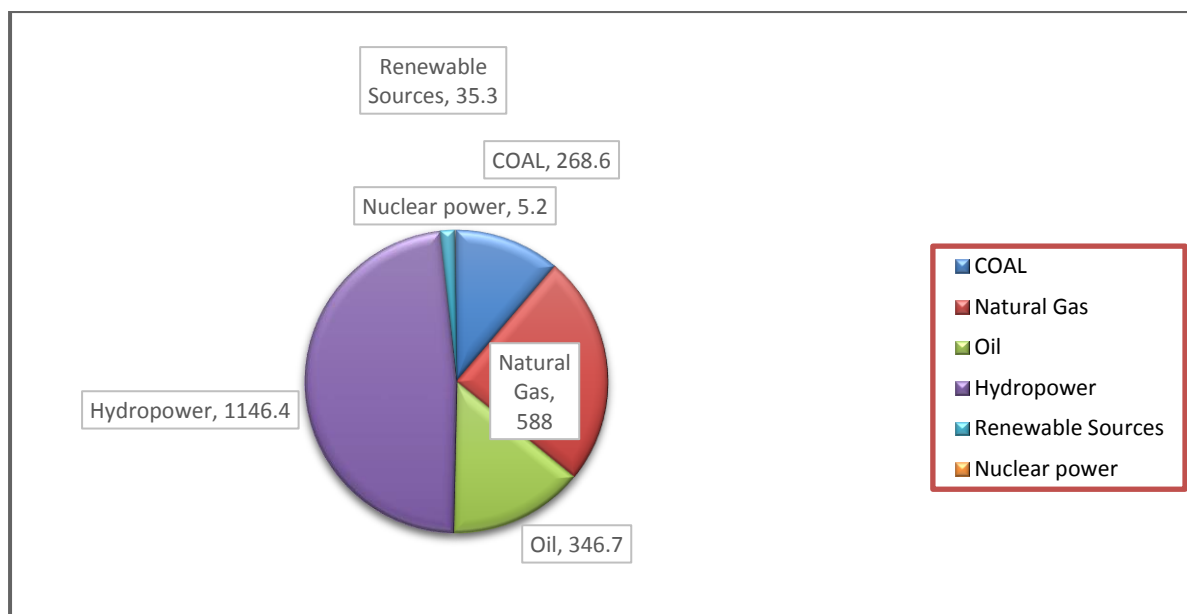
#### **4.5 Private participation in the electricity generation sector in Africa**

The first country in Africa to see private sector participation in the electricity sector was the Ivory Coast (cote d' Ivoire) in 1989. Ever since, there has been an increase in private sector participation in the electricity power sector in Africa. Most countries in the region began privatizing and unbundling their vertically integrated state-owned utilities in the late 1990s into different segments – generation, transmission, and distribution. The aim of these reforms was to promote competition and to facilitate the entry of private investors into the sector. Most countries in the region involve the private sector in one of the following ways - management/ lease contracts, concessions, Greenfield projects, divestiture, privatization, unbundling and regulatory changes.

As a result of private participation in the electricity sector of 39 countries in the region, the flow of private investment into the sector rose to \$93,413.8 billion, with 197 electricity generation projects completed during the period 1990 – 2012, representing 45 percent of average fixed capital formation (*see figure 4.3*). South Africa is clear at the top of the table, showing that the majority of the power sector generation plant/station projects are located in the country. For most countries, the value of generation projects relative to the size of their economies is not large. However, for four countries (Uganda, Kenya, Rwanda and Tanzania) it is greater than 10 percent while for another four countries (Namibia, Guinea-Bissau, Malawi and Lesotho) it is less than 4 percent. We will explore in more detail private investment in the power sector in chapter five.



**Figure 4.3:** Electricity Generation Projects 1990 -2012  
 Source: Authors' calculations based on data from the PPI Database/World Bank.



**Figure 4.4:** Sources of Electricity generation in Africa 2011

**Source:** Authors' calculations based on data from the PPI Database and World Bank African development Indicator.

Hydropower as a source for electricity generation still dominates the sector (*see figure 4.4*), contributing approximately 48% of total African electricity production. The top 10 largest markets for hydropower in the region in terms of capacity are Mozambique, Zambia, Congo DR, Ethiopia, Namibia, Sudan, Togo, Zimbabwe, Cameroon and Angola. In Mozambique, for example, an estimated 27–30GW of new hydropower and 2–3GW of pumped storage capacity was commissioned during 2012. In many cases, the growth in hydropower was facilitated by lavish renewable energy support policies from multinational agencies (World Energy Council 2013).

## 4.6 Methodology

There are three main methods used in analysing electricity reform as identified by Jamasb et al (2004): an econometric approach, efficiency and productivity analysis methods, and comparative case studies. The first method (the econometric approach) is best suited to an analysis and testing of hypotheses on electricity reform and performance in the power generation sector. The second approach (the efficiency and productivity method) is best used when measuring the effectiveness with which inputs are transformed into outputs, relative to best practice. The third method of single-country or cross-country studies and case studies, Jamasb et al. (2004) maintain is suitable when an in-depth investigation or qualitative analysis is required. Thus, within these three methods, our study draws upon the first and an element of the third category. We will use both econometric and a cross-country approach to investigate to what extent do market-oriented electricity reform policies impact on power generation performance, focusing on 30 African countries.

As stated by Jamasb et al. (2004) there is no definitive accepted measurement criteria or indicators for monitoring the progress of power sector reforms, impact and performance. Since our goal in this study is to propose a framework to analyse the impact of market-oriented reforms on power generation in African countries, we are faced with a similar problem. To resolve this, we first state possible hypotheses we need to test if we are to understand the impact of liberalization policies on power generation. Second, we need to make choices on which indicators<sup>76</sup> to use in this study and lastly, we need to specify a workable method(s) to measure them.

This methodology represents a novelty with respect to most empirical studies in this field. To date, there has been limited empirical study that includes generation cost in the analysis, particularly for the Africa region. (Vagliasindi and Besant-Jones, (2013).

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<sup>76</sup> For an indicator to be useful it needs to be based on a clear definition. Also, is it expressed in physical, monetary or qualitative terms? Most economic and utility indicators, such as consumption, costs, prices, and income, capacity, transmission and distribution losses are measured in some form of monetary and/or physical unit. However, major electricity reform variables such as privatization, regulation, unbundling the market, open/third party access are qualitative in nature. We account for these variables through the use of dummy variables.

#### 4.6.1 The Data Set

This study made use of a balanced panel data set. We used secondary data sourced from the World Bank Development Indicators, the World Bank Benchmarking database (2009), the US Energy Information Administration, the International Energy Agency, the African Development Bank, and the World Energy Council. Our analysis focuses on key electricity performance indicators such as net electricity generation, installed electricity generation capacity, electricity generation per employee (*a proxy for labour productivity*) and generation utilization. These indicators capture the actual electricity available to each country in the sample.

Table 4.2 presents the definitions of the variables used in this study. Our data set is based on a panel of 30 African countries<sup>77</sup> for the period 1989 to 2012. This study uses the level of private investment in the electricity generation sector as a measure of privatization instead of using a discrete/dummy variable of 1 or 0 as in other studies, (except for Balza (2013)). The benefit of this method is that it will capture the intensity of the privatization process<sup>78</sup> better than the former.

The year 1989 was selected as the start date because electricity reform was initiated for the first time in the Ivory Coast and the year 2012 represented the last year for which data were available at the time the research was conducted. It is important to note the reform process is on-going in some countries, so not all data exist for all of the years for all countries. Our panel dataset covers 30 countries for 24 years, thus, the total of a number of observations is 720 (30 x 24).

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<sup>77</sup> Algeria, Angola, Botswana, Burkina Faso, Cape Verde, Cameroon, Congo Dem. Rep, Congo Rep, Cote d'Ivoire, Egypt, Ethiopia, Gabon, Ghana, Kenya, Madagascar, Malawi, Mali, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Rwanda, Senegal, South Africa, Tanzania, Tunisia, Uganda, Zambia and Zimbabwe

<sup>78</sup> This study uses the World Bank's Private Participation in Infrastructure (PPI) database. The PPI includes electricity projects in only the generation sector.

## 4.6.2. Core Indicators and Variable Derivation

**Table 4.2:** The variables Description

Variables	Variable description	Notation	Sources
Electricity net generation per capita	Total electricity generated by the utility or generation company and independent power producers (IPPs) excluding that of captive generation (industrial or commercial “inside the fence”, e.g. mines, factories) divided by the total population. Measured on GWh. We transformed this variable using natural logarithms	lnGEN	EIA
Installed electricity generation capacity per capita	The maximum rated output of all the utility generators in a country divided by the population. It is expressed in megawatts (MW). We transformed this variable using natural logarithms	lnGENCAP	EIA
Electricity generation per employee	Total electricity generated divided by a number of full-time equivalent employee in the industry. This is a proxy for labour productivity. We transformed this variable using natural logarithms	lnGENEMP	derived
Generation Utilization index	$\frac{\text{Actual Electricity net generation (MW)}}{\text{Installed generation capacity (MW)}} \times \frac{100}{1}$ We transformed this variable with natural logarithms	lnGENUTIZ	derived
Privatization	Share capacity of private-owned capacities (%)	PRIVTIZ	World Bank
Regulation	0 = No independent or autonomous regulatory Agency. 1 = Independent/autonomous regulatory Agency.	REGU	dummy
Competition	Percentage share of top 3 generating companies by capacity	COMPET	derived
Unbundling	0 = Vertical Integration 1 = Restructuring through vertical separation	UNBUND	dummy
Electricity Law <sup>79</sup> Amendment	0 = no electricity law/act amendment 1 = There is an electricity law/act amendment	ELELAW	dummy
IPPs <sup>80</sup>	0 = No independent power producer forbidden by law 1 = There is Independent power producer	IPPs	dummy
Generation cost	$\frac{\text{Total expenditure (US\$)}}{\text{Total Energy delivered (kwh)}}$ We transformed this variable with natural logarithms	lnGENCOST	derived
Gross Domestic Product per capita	Measured GDP per capita (in US\$ million) and at 2010 constant prices. We transformed this variable using natural logarithms	lnGDP	World Bank
Population	The number of people living a country at a particular period of time. We transformed this variable using natural logarithms	lnPOPUL	World Bank
Industrial Output	Manufacturing output as a percentage of GDP (%). We transformed this variable using natural logarithms	lnINDUPUT	World Bank

<sup>79</sup> Electricity law/act amendment is when a country's national law making bodies amend an existing act/law and is passes into law.

<sup>80</sup> IPPs are considered a quick and relatively easy solution to persistent supply constraints experienced in the African region (APEC Energy Working Group, 1997). It is important to note that IPPs should be established before sector unbundling. Establishment of an independent regulator is not a prerequisite since in the IPP contracts there are laid down rules in the form of a regulation.

#### 4.7 Model Specification

Our panel data analysis has three more-or-less independent approaches. They are as follows: (i) independently pooled panels, (ii) Fixed effects models, and (iii) Random effects models.

The choice made by these methods depends upon the objective of our study and the relevant tests we want to carry out. We start with the standard panel data regression equation below to analyse the impact of electricity reforms on power generation performance.

$$Y_{it} = \beta_1 + \sum_{j=2}^k \beta_j X_{jit} + \sum_{p=1}^S \gamma_p Z_{pi} + \delta t + \varepsilon_{it} \quad [4.1]$$

In the model,  $i$  and  $t$  represent a unit of observation and time period respectively.  $j$  and  $p$  are indices used to differentiate between observed and unobserved variables.  $X_{ji}$  and  $Z_{pi}$  represent observed and unobserved variables respectively.  $X_{ji}$  includes both reform indicators and control variables.  $Y_{it}$  is the dependent variable that is, total net electricity generation, installed generation capacity, net electricity generation per employee - *labour productivity*, and electricity generation/average capacity - *capacity utilization Index*, while  $\varepsilon$  is the disturbance term and  $t$  is the time trend term. Because the  $Z_{pi}$  variables are unobserved, there are no means of obtaining information about the  $\sum \gamma_p Z_{pi}$  component of the model. For convenience, we introduce a term  $\alpha_i$ , known as the unobserved effect, representing the joint impact of the  $Z_{pi}$  variables on  $Y_{it}$ . So, our model may be rewritten as follows:

$$Y_{it} = \beta_1 + \sum_{j=2}^k \beta_j X_{jit} + \alpha_i + \delta t + \varepsilon_{it} \quad [4.2]$$

The  $\alpha_i$  element is vitally important in this analysis. If our control variables are so comprehensive that they capture all relevant characteristics/features, there will be no relevant unobserved characteristics. In that case, the  $\alpha_i$  term may be dropped and pooled data regression (OLS) will be used to fit the model, treating all the observations for all time periods as a single sample. However, since we are not sure whether the control variables in our models capture all relevant characteristics of the countries, we cannot directly carry out a pooled data regression of  $Y$  on  $X$ . If we were to do so, it would generate an omitted variable bias. Therefore, we prefer to use either a Fixed Effects (FE) or Random Effects (RE) regression. In the FE model, the country-specific unobserved effects ( $\alpha_i$ ) are assumed to be the fixed parameters to be estimated. In the RE model, the country-specific effects ( $\alpha_i$ ) are treated as stochastic.

There are about 35 countries in the African region where one form of market-reform or other has been initiated in their electricity power industry but data is available only for 30 countries. Moreover, since countries in the region did not start reforms at the same time, it is



important to focus on those with sufficient data. Therefore, we cannot be sure ex-ante whether the observations in our model may be described as being a random sample from a given population, and so cannot directly decide on which model specification - (Fixed effect or Random effect) to use. It will be decided by conducting a Hausman test (Erdogdu 2011).

We formulate a regression model based on Zhang *et al*'s (2008) approach, as stated below, to analyse the impact of liberalization policies on the power generation sub-sector in Africa.

$$\ln Y_{it} = \varphi_i + \beta_1(\mathbf{R}_{it}) + \beta_2(\mathbf{P}_{it}) + \beta_3(\mathbf{Cm}_{it}) + \beta_4(\mathbf{U}_{it}) + \delta(X)_{it} + v_i + u_t + \varepsilon_{it} \quad [4.3]$$

Where  $Y_{it}$  is the electricity generation performance indicator,  $\varphi_i$  is the intercept, and  $\mathbf{P}$ ,  $\mathbf{R}$ ,  $\mathbf{Cm}$  and  $\mathbf{U}$  are the main reform variables,  $X_{it}$  denotes the control variables (Electricity act/law, industrial output, GDP per capita, generation cost, IPPs).  $v_i$  represents the unit-specific residual that differs between countries but remains constant overtime for any particular country; and  $u_t$  stands for the time effect and differs across years, but remains constant for all selected countries in a given year;  $\varepsilon_{it}$  captures the error (disturbance) term.

Based on our prior expectations, we estimate model [4.4], to explore the two variable interaction effects.

$$\ln Y_{it} = \varphi_i + \beta_1 (R_{it}) + \beta_2 (P_{it}) + \beta_3 (Cm_{it}) + \beta_4 (U_{it}) + \beta_5 (R_{it} P_{it}) + \beta_6 (R_{it} Cm_{it}) + \beta_7 (R_{it} U_{it}) + \beta_8 (P_{it} Cm_{it}) + \beta_9 (P_{it} U_{it}) + \beta_{10} (Cm_{it} U_{it}) + \delta(X)_{it} + v_i + u_t + \varepsilon_{it} \quad [4.4]$$

Furthermore, we will estimate both three and four variable interaction effects before selecting the most appropriate model specification.

$$\ln Y_{it} = \varphi_i + \beta_1 (R_{it}) + \beta_2 (P_{it}) + \beta_3 (Cm_{it}) + \beta_4 (U_{it}) + \beta_5 (R_{it} P_{it}) + \beta_6 (R_{it} Cm_{it}) + \beta_7 (R_{it} U_{it}) + \beta_8 (P_{it} Cm_{it}) + \beta_9 (P_{it} U_{it}) + \beta_{10} (Cm_{it} U_{it}) + \beta_{11} (R_{it} P_{it} Cm_{it}) + \beta_{12} (R_{it} P_{it} U_{it}) + \beta_{13} (R_{it} Cm_{it} U_{it}) + \beta_{14} (P_{it} Cm_{it} U_{it}) + \delta(X)_{it} + v_i + u_t + \varepsilon_{it} \quad [4.5]$$

$$\ln Y_{it} = \varphi_i + \beta_1 (R_{it}) + \beta_2 (P_{it}) + \beta_3 (Cm_{it}) + \beta_4 (U_{it}) + \beta_5 (R_{it} P_{it}) + \beta_6 (R_{it} Cm_{it}) + \beta_7 (R_{it} U_{it}) + \beta_8 (P_{it} Cm_{it}) + \beta_9 (P_{it} U_{it}) + \beta_{10} (Cm_{it} U_{it}) + \beta_{11} (R_{it} P_{it} Cm_{it}) + \beta_{12} (R_{it} P_{it} U_{it}) + \beta_{13} (R_{it} Cm_{it} U_{it}) + \beta_{14} (P_{it} Cm_{it} U_{it}) + \beta_{15} (R_{it} Cm_{it} P_{it} U_{it}) + \delta(X)_{it} + v_i + u_t + \varepsilon_{it} \quad [4.6]$$

In equation 4.3 to 4.6 we allowed for both the separate effects of the reform variables and their interactions (joint) effect to be examined. Thus, the impact of a reform variable is permitted to be influenced by the presence or absence of another reform variable. In other words, their effects may reinforce one another in terms of the performance of the electricity generation indicators. Reform variables may not have sufficient individual impact on the electricity generation indicators which is why is important to consider interaction effects in

our regression models. Rajan and Zingales (1998) employed interaction effects (terms) in their regression analysis of financial dependence and growth.

#### 4.7.1 A Priori expectations

We expect the regulation variable to be exerting a positive influence as establishing a regulatory agency is sufficient to show the government is serious in its quest to allow private sector participation. Implication:  $\beta_1 > 0$

Second, we expect in (equation 4.3) that as countries privatize their power generation sector (that is move from a state-owned utility to private-owned oriented), the total net electricity generation, installed capacity, labour productivity and generating capacity utilization will significantly improve. Implication:  $\beta_2 > 0$

Third, as countries move further away from vertical integration to a more competitive power generation sector, labour productivity, and total net electricity generation and installed capacity will improve. Implication:  $\beta_3 > 0$

Likewise, we expect a positive consequence of unbundling of the vertically integrated state-owned power utilities (i.e., an increase in the level of unbundling in the power generation sector promotes a higher rate of capacity utilization, and greater in electricity generation, labour productivity and installed capacity). Implication:  $\beta_4 > 0$

In addition, (equation 4.4 to 4.6) we expect the interaction effects<sup>81</sup> of the reform variables on the performance indicators to be positive and significant in improving all the electricity generation performance indicators such as (total net electricity generation, installed capacity, labour productivity and the utilization of generation output). Zhang et al. (2008), found that an allowance for interaction effects, produces stronger positive results. In other words, reforming countries are expected to benefit from adopting more than one reforms as it is a sign of total commitment which strengthens the system and promotes growth ( $Z > \beta_j > 0$ ,  $j = 5, 6, \dots, 15$ )

#### 4.8 Research Hypotheses

Hypotheses (1 - 4) concerns market-oriented reforms and performance outcomes of the electricity generation sector. As we know, electricity generation is capital-intensive which

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<sup>81</sup> That is different form of interaction effect models - Two by two – Eq 4.4; three by three – Eq.4.5 and four by four-Eq. 4.6

involves long-term sunk capital (investments). Therefore, the implementation of reform in the form of establishing an autonomous regulatory body, vertical unbundling, introduction of competition and privatizing the sector is expected to be significantly associated with an increase in generation, labour productivity, higher capacity utilization, expansion of installed capacity.

However, the key aspect of reform is that it leads to ‘an increase’ in total electricity generation per capita, installed capacity, labour productivity, and the capacity utilization rate. So, when compared to non-reformed markets, the former hold an edge over the latter in that the new entrants can spot opportunities that incumbents have not exploited. Also, a more competitive market is generally more conducive to better investment decisions and innovative outcomes. Hence, the below hypotheses will be tested to answer our research questions.

#### ***First Hypothesis – Regulation***

The main aim of establishing a regulatory body is to protect consumers from monopolistic exploitation, to provide investors with protection from arbitrary political decisions, and to promote efficient operation and investment (Laffont & Triole, 1993). Hypothesis: *The presence of an independent regulatory agency/body in the power sector will lead to an increase in labour productivity and generation capacity utilization rate, as well as an increase in total net electric power generation and installed capacity.*

#### ***Second Hypothesis – Privatization***

Privatization entails involving private sector capital in what were predominantly state-owned enterprises, either through partial or full sale of the shares owned by the government. We ask whether privatization leads to an increase in power generation and availability (e.g., by improving generator plant maintenance) and also reduces wastage (enhancing higher labour productivity and efficiency). Hypothesis: *Countries that privatized their power generation will witness an increase in electricity generation, labour productivity, and capital utilization and so will attract more foreign capital.*

#### ***Third Hypothesis – Competition***

In utility industries, competition is regarded as a stimulus that enhances operational and technical efficiency (Leibenstein, 1966). In a competitive market, there is perfect information

on cost and price about the market. If firms in the industry are making excess profits/gain, and there is no barrier to entry, more firms will access the market (i.e. it will lead more firms to enter the market). Thus, it is expected that with more private producers in the power generation sector this will lead to an increase in electricity generation, lower the price and cost, and thereby increase the quantity of electricity demanded. Hypothesis: *Competition will enhance labour productivity of the workers, increase capacity utilization and electricity generation too.*

#### ***Fourth Hypothesis – Unbundling***

Unbundling is the process of separating a vertically integrated state-owned power utility into different entities such as (generation, transmission, and distribution or creating regional companies within a country). Hypothesis: *Unbundling will promote an increase in electricity generation, capacity utilization and efficiency.*

### **4.9 Preliminary evidence**

The selected countries in this study cover the entire five regions in the continent<sup>82</sup>. Moreover, using descriptive statistics is more meaningful for continuous than discrete variables, for which information is lost when assigning data to categories.

Table 4.3 shows the descriptive summary of the performance indicators for the power generation segment in the region. There were arranged in order of gross domestic product per capita, which shows Botswana top in term of GDP per capita in the region, but South Africa has the highest electricity generation (GMh), installed Capacity, labour productivity and generating capacity utilization ratio. Thus, South Africa contributes 47% of the total electricity generation in the region. Likewise, in terms of installed capacities in the region, South Africa have 40 MW, Egypt which is second in the table with 18 MW and the last is the island of Cape Verde with 0.05MW.

Furthermore, we found out that countries with electricity generation rates of less than 10 GMh of the population have consistently lower GDP per capita. The only countries that have electricity generation of less than 10 GMh with higher GDP per capita are those with significant wealth in natural resources, such as Angola, Botswana, Gabon and Namibia (table 4.3).

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<sup>82</sup> Central Africa, East Africa, North Africa, Southern Africa and the West Africa.

**Table 4.3: Descriptive summary of the Power generation performance Indicators**

	Country	Electricity generation per capita (GMh)	Installed Capacity per capita (MW)	Labour Productivity per employee (MW)	Generation capacity utilization index (MW)
1	Botswana	4.72039E-07	0.164	0.0021	510.936
2	Gabon	1.10569E-06	0.379	0.0022	357.207
3	Mauritius	1.34519E-06	0.666	0.0009	239.902
4	South Africa	4.59123E-06	40.421	0.0059	497.548
5	Namibia	5.14451E-07	0.361	0.0027	465.932
6	Tunisia	1.04362E-06	2.569	0.0026	394.135
7	Algeria	8.24764E-07	7.269	0.0013	368.659
8	Cape Verde	3.55675E-07	0.055	0.0008	282.964
9	Angola	1.51296E-07	0.825	0.0031	275.938
10	Morocco	5.14652E-07	4.568	0.0081	331.024
11	Congo, Rep.	1.53766E-07	0.129	0.0012	245.565
12	Egypt	1.19577E-06	18.222	0.0026	440.047
13	Cote d'Ivoire	2.55879E-07	1.195	0.0026	352.178
14	Nigeria	1.39743E-07	5.867	0.0005	304.160
15	Zambia	8.27281E-07	1.716	0.0021	499.731
16	Cameroon	2.30078E-07	0.858	0.0011	448.233
17	Senegal	1.62499E-07	0.382	0.0008	452.242
18	Ghana	3.65732E-07	1.519	0.0008	475.109
19	Kenya	1.53015E-07	1.164	0.0007	437.151
20	Tanzania	7.88001E-08	0.741	0.0006	380.328
21	Burkina Faso	3.00473E-08	0.159	0.0009	241.336
22	Mali	4.91868E-08	0.198	0.0004	227.637
23	Zimbabwe	6.53004E-07	2.030	0.0012	383.946
24	Mozambique	3.80196E-07	2.368	0.0026	338.585
25	Uganda	5.91289E-08	0.327	0.0010	511.347
26	Rwanda	2.19722E-08	0.049	0.0005	356.362
27	Ethiopia	3.54284E-08	0.809	0.0003	322.072
28	Congo, DR	1.32226E-07	2.628	0.0005	326.936
29	Madagascar	5.43147E-08	0.295	0.0013	309.764
30	Malawi	1.02223E-07	0.254	0.0006	500.169

Table 4.4 illustrates the link between the reform variables and the performance indicators in the power generation segment. However, we only compare countries that have adopted similar reforms and exclude those that have not. With regard to regulation, there were 23 countries in our sample that established a regulatory authority to properly monitor and control the activities of utilities operating in the sector. On average, 15 experienced a positive outcome (i.e. the percentage change in average annual electricity generation from before to after the reform was greater than zero), 8 countries experienced a negative outcome, while 7 countries did not introduce an independent regulatory authority.

**Table 4.4: Descriptive statistics of the performance indicators and reform variables<sup>83</sup>**

Performance Indicators	Category	Key Reform Indicators			
		Regulation	Competition	Unbundling	Privatisation
Total Electricity Generation	Max. %Δ (country)	293.15 Mozambique	237.31 Cape Verde	143.48 Ethiopia	936.39 Mali
	Min. %Δ (country)	-85.74 Namibia	2.49 Zimbabwe	-88.62 Namibia	-81.59 Namibia
	Median %Δ	74.54	73.32	64.18	-36.43
Installed Capacity	Max. %Δ (country)	187.55 Cape Verde	246.95 Ethiopia	201.97 Ethiopia	223.66 Ethiopia
	Min. %Δ (country)	-12.62 Namibia	1.34 Nigeria	-99.66 Mali	-27.32 Botswana
	Median %Δ	44.19%	56.82	41.69	58.27
Labour Productivity	Max. %Δ (country)	1990.9 Gabon	355.88 Cote d'Ivoire	1550 Cote d'Ivoire	400 Mozambique
	Min. %Δ (country)	-0.22 Cape Verde	11.36 Cape Verde	-84.72 Ghana	-91.5 Zimbabwe
	Median %Δ	80	58.57	63.33	15.5
Capacity Utilisation	Max. %Δ (country)	283.94 Mozambique	127.83% Cote d'Ivoire	46.31 Nigeria	447.74 Mozambique
	Min. %Δ (country)	-42.46 Mali	-42.19 Mali	-36.96 Mali	-99.9 Mali
	Median %Δ	17.10	5.43	9.98	-2.78

\*\* %Δ signifies the average percentage change in the average yearly value of the performance indicator from the period before the implementation of the reform measure to the period after its implementation. The impact figures were derived from the average year of reform minus the average year of non-reform divided by the average year of non-reform multiplied by 100. Maximum (Max) indicates the largest positive percentage while Minimum (Min) indicates the largest negative percentage or smallest positive percentage. Also, the Median indicates the middle percentage (having ranked the countries from maximum to minimum), i.e., the percentage for which the same number of values are greater and less than this.

In the same way, when considering competition, 20 countries introduced competition into their power generation sector, while 10 have still to do so. Out of the 20, on the average 16

<sup>83</sup> The performance indicators are their raw form not per capita

countries had a positive outcome and 4 had a negative outcome. Also, when reviewing unbundling, 17 countries have implemented unbundling in their power generation, out of which 9 experienced a positive outcome and 8 had a negative outcome. We treat the shared capacity of private ownership in power generation as a proxy for privatization. Out of the 30 countries, 13 had a positive outcome, while for 17 the impact of the reform was negative.

#### 4.10 Empirical Results and Analysis

Most of the work in this field used a simple estimation procedure (Zhang et al. 2008 started with smaller equations, before moving to bigger ones), but in this paper we adopted the more orthodox procedure of estimation found in econometric models (i.e. we start with the more general equation (4.6), sequentially dropping insignificant variables based on t-test specifications until we arrived at a preferable model). The advantage of using this procedure is that the general equation (4.6) might be 'over-parameterised' (i.e. Containing variables that play little or no role in terms of statistical significance), and so is not in a form which has any explicit economic interpretation. It is necessary to move from a general to specific model to overcome these weaknesses.

We produced estimations showing the relationship between each of the dependent variables, namely, *total net electricity generation per capita*, *installed generation per capita*, *electricity generation per employee*, and *generation capacity utilization* and both the reform and control variables (See Table 4.5 for the estimation outcomes). Our empirical results reflect two sets of relationship: First, the individual reform variable's impact on electricity power generation performance indicators. Second, the interaction effect on the electricity power generation performance indicators. We will base our analysis and interpretation of estimation results wholly on the interaction effect model (i.e., the specified model). Also, the adjusted R-squared (shown in equation 2, 4 and 6 over 70 percent of the variation in the electricity generation performance indicators).

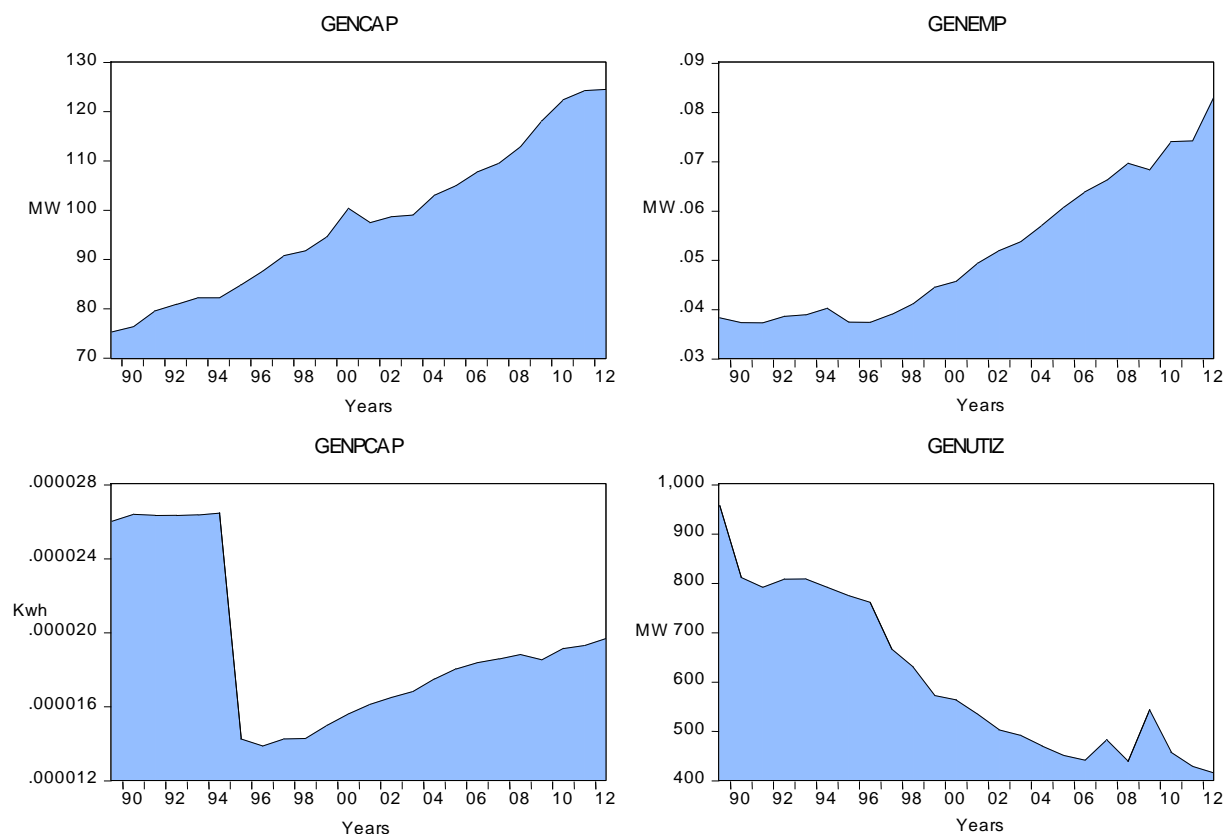
Furthermore, we conducted Hausman test to select the preferred model. The p-value for the test show less than 1 per cent indicating that the random effect is not appropriate, thus the fixed effect specification is preferred. We tested the stationarity of the variables, and the time series proves to be stationary over the period covered (see figure 4.5) Evidence from the figure suggests that each time series is non-stationary.

Table 4.5: The estimation results output

Explanatory Variables	Electricity net generation per capita (logGenpcap)		Installed electricity generation capacity per capita (lngencap)		Electricity generation per employee (lngenemp)		Generation Utilization (Ingenutiliz)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	Eq. (4.3)	(4.4)	Eq. (4.3)	(4.4)	Eq. (4.3)	(4.4)	Eq. (4.3)	(4.4)
R	0.131*** (0.051)	0.098 (0.068)	0.0001 (0.028)	0.003 (0.028)	-0.024 (0.125)	2.023*** (0.448)	0.112** (0.457)	0.107* (0.059)
P	0.0007* (0.0004)	0.0003 (0.0005)	-0.0001 (0.0002)	-0.0001 (0.0002)	0.001 (0.009)	0.001 (0.0009)	0.001 (0.0003)	0.002* (0.001)
CM	0.003*** (0.001)	0.003* (0.002)	-0.0002 (0.0007)	0.002* (0.001)	-0.003 (0.003)	-0.003 (0.004)	0.002* (0.001)	0.004*** (0.002)
U	-0.179*** (0.058)	-0.017 (0.090)	0.121** (0.033)	0.333*** (0.088)	0.113 (0.147)	0.098 (0.224)	-0.229*** (0.054)	-0.106 (0.080)
IPP	0.002 (0.069)	dropped	0.084** (0.037)	0.075** (0.037)	0.112 (0.163)	0.082 (0.162)	-0.074 (0.059)	-0.1004* (0.061)
ELELAW	-0.062 (0.062)	-0.062 (0.048)	-0.005 (0.035)	-0.005 (0.035)	-0.328** (0.154)	-0.285** (0.149)	-0.029 (0.056)	-0.032 (0.057)
LNGENCOST	-0.028 (0.033)	dropped	0.016 (0.017)	0.0167 (0.017)	0.179* (0.079)	0.130* (0.077)	-0.049* (0.029)	-0.043 (0.028)
LNGDP	0.632*** (0.085)	0.666*** (0.085)	0.579*** (0.473)	0.562*** (0.048)	-0.265 (0.208)	0.028 (0.205)	0.031 (0.076)	0.026 (0.076)
LNINDUPUT	0.031 (0.033)	0.051 (0.032)	-0.052*** (0.017)	-0.049*** (0.017)	0.142* (0.078)	0.131* (0.077)	0.114*** (0.029)	0.126*** (0.029)
RP		0.002** (0.0009)						0.001* (0.0007)
RU		-0.842*** (0.266)				-2.934*** (0.491)		-0.187** (0.084)
PCM								-3.585** (1.605)
RPU		0.006** (0.002)						
CMU				-0.003*** (0.001)				
RCMU		0.0085** (0.003)				-0.037*** (0.008)		
RCMU						0.049*** (0.007)		
Adjusted R-squared	0.92	0.92	0.97	0.97	0.79	0.78	0.46	0.45
Preferred Model	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect
Number of Obs	720	720	720	720	720	720	720	720

N/B: \*Indicates significant at the 10% level; \*\*significant at the 5% level; \*\*\* significant at the 1% level. Standard error in parentheses.





**Figure 4.5:** Time series plots for the key electricity generation performance indicators

African region<sup>84</sup> reflects a region in serious need to transform its electricity market, as the region's population is on the rise, with its 13.6 per cent of the total world population, 43 per cent of its population without access to electricity (World Bank 2014). Our results indicates that countries in which the government has shown more commitment in terms of reform of the sector has experienced increase in total net electricity generation per capita, installed capacity per capita and labour productivity. *Figure 4.5* shows trends of the key electricity performance indicators over time. The total net electricity generation per capita in the region experienced great decline in early 1990s as a result of civil unrest in many African countries, which affected the electricity generation infrastructure, but recovery started in 1994. Similarly, there is continuous increase in installed capacity and the employee productivity in the industry in the region over time. But the rate of electricity generation capacity utilisation has been decreasing. The case of Namibia is due to increase in bulk electricity purchase by the mining activities, which make up/constitutes to 45 per cent (Konrad, Adenauer and Stiffing; 2012).

<sup>84</sup> This study focus only on 30 countries

#### 4.10.1 Total net Electricity Generation per capita

In Model 1, our test is to establish whether an increase in total net electricity generation can be attributed to market-oriented reform indicators. To do this, we will concentrate our interpretation on equation 2 (while equation 1 is the individual effect<sup>85</sup>). Our results show that the depth level of competition in the industry the tendency it individually significant and positive and are associated with an increase in total net electricity generation per capita, although privatisation was not significant. Unbundling is statistically not significant while negatively associated with total net electricity generation. The unexpected negative sign can be explained by the fact that only a few African countries have their power sector vertically unbundled. It is important to note that unbundling is not an end itself, but rather a means to achieve better performance (Vagliasindi & Besant-Jones 2013). Meanwhile, the presence of an independent regulator is positive but statistically insignificant, suggesting that establishing a regulatory agency/body to monitor the power generation sector alone is not sufficient to lead to an increase in total net electricity generation per capita in the region.

In contrast, when independent regulation co-exists with privatization our result confirms there is a positive correlation statistically significant at the 1% level. In other words, although regulation was insignificant when considered alone when it interacts with privatization it is significant, indicating that when a country introduces more than one reform it becomes more effective. Thus, when there is an increase in the share of private-owned utility generators this overshadows the negative effect of regulation alone. Based on this we conclude that privatization together with regulatory reforms is linked with an increase in total net electricity generation per capita. This finding is consistent with that of Zhang et al. (2008) and Steiner (2001).

Also, when regulation interacts with unbundling, our result showed a negative but statistically significant impact. This is an unexpected outcome, but can be attributed to the poor level of independence enjoyed by the regulators in many African countries, as many of the commissioners fail to complete their tenure in office before being removed or are put under pressure to resign (Eberhard et al 2008). Thus, the gap between law and practice in Africa is wide. Also the little unbundling seen in the regional power generation sector has contributed to a poor payback, as most countries in the region (especially Sub-Saharan Africa) have a small power system which makes it difficult to have effective unbundling. Restructuring the

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<sup>85</sup> Equation 1, 3, 5, and 7 are individual effects, we only use them for comparison purposes in this study.

power generation sector to foster competition makes sense only for countries able to operate large/multiple generators at an efficient scale.

As expected, the log of GDP per capita was positive and correlated with an increase in total net electricity generation per capita, which supports the theory that an improved economy results in higher average electricity generation per citizen. Meanwhile, the electricity law and IPP were statistically insignificant and negative, thus, meaning not too much should be read into these results.

#### **4.10.2 Installed Generation capacity per capita**

Equations 3 and 4 show the outcome of the reform and control variables on installed capacity per capita in the electric power generation sector. Equation 4 shows unbundling on *its own* is statistically significant at the 1% level confirming that unbundling is associated with better power generation sector performance. This is also consistent with our hypothesis that unbundling promotes efficiency and an increase in installed capacity expansion.

Turning to the effects of regulation, the presence of an independent regulator is positively associated with an increase in installed capacity in the sector, although it is not statistically significant. Privatization has a negative sign and is statistically insignificant, which confirms the findings of Zhang et al (2008). Indeed positive effects of (regulation and privatisation) have the unexpected sign, suggesting poor payback from this reform (i.e. on their own they may actually reduce installed capacity per capita). In other words, the insignificance of regulation and privatization can be attributed to the government's overbearing influence in the sector, coupled with control of regulatory agencies and the partial scale of privatization in the power sector in the region. A study conducted by the World Bank in (2005) notes the damaging impact of poor regulation in electricity markets on economic growth (World Bank 2005).

In reality, the emphasis on independent regulation in the region is yet to be achieved, as regulators are far from being independent in many of the countries. Also, privatization of the power generation sector in many African countries can take the form of patronage, by the government to their supporters. For instance in Morocco the government sold power generation utilities to Moroccan elites in exchange for their support (Hibon 2005).

The competition (individual) coefficients (*equation 4.4 only*) were statistically significant and positively associated with an expansion in installed capacity in the power generation sector.

This corresponds to the findings of Zhang et.al (2008). Under the interaction effect model, competition and unbundling were statistically significant, but showed a negative association with installed capacity expansion which contradicts our hypothesis. In other words, the effect of competition on power generation is reduced by an increase in the degree of vertical unbundling of the sector.

The effects of GDP per capita on capacity expansion are statistically significant and positive. These results are in line with our a priori expectation, as African countries experience increases in GDP per capita, it becomes a priority for the government to expand their installed capacity through in-house generation. Thus, in-house generation contributes around 9 percent of the total installed generating capacity in the region (Foster & Steinbuks, 2009), although is not sufficient for the growing population. The presence of independent power producers also leads to an increase in installed capacity. This is in the form of private firms engaged in refurbishment<sup>86</sup> of old generation plants and building new ones (Rosnes et al 2009). As we saw in our results, IPPs was significant and positive in both columns 3 and 4. However, the coefficient of manufacturing output was statistically significant but has a negative sign. This could be as a result of the low productivity and underutilization of the generating capacity which dominates the power generating sector in the region.

#### **4.10.3 Electricity generation per employee**

In Model 3, we estimated electricity generation per employee (a proxy of labour productivity) and found that, of the four key reform variables used, only regulation was statistically significant and positively associated with an increase in labour productivity (i.e. there is a strong effect of an independent regulator on the latter). However when considering the interaction effects, this shows that regulation and unbundling were statistically significant, but negatively correlated with employee or staff productivity. The negative correlation signifies a reduction in the effect of regulation due to increased unbundling. This could be attributed to poor regulatory institutions and limited unbundling of the sector in the region, which has affected the productivity of the employees. It is an important fact that many African countries adopted partial unbundling and, as a result, the partial form of vertical unbundling undertaken does not appear to drive improvements in labour productivity. The most likely reason for this is that sometimes regulators are directed by the government to

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<sup>86</sup> Refurbishment refers to efforts either to prolong the life of an outdated plant whose operating life is coming to an end by restoring it to full operational status, or to repair generation assets that have been seriously damaged during war.

embark on policies that are not healthy for the sector. For example, Government ministries may direct the agencies to increase the number of their staff, in order to reward their supporters (i.e. leads to overstaffing).

Also, the outcome of combining regulation and unbundling (RU) did not conform to our expected sign. The interaction coefficient was statistically significant but negatively associated with an increase in labour productivity. That is, instead of an increase in the productivity of staff as the number of private generators rises, productivity was decreasing (contrary to our previous result). The situation in most African countries is that of a hybrid power market (i.e. the state-owned utility still retains the dominant role in the sector), serving as a single buyer of electricity. We know that concessions, leases and management contracts in the power generation sector contribute to an increase in electricity generation per capita, given that labour productivity is driven by employment. Thus, the Government's overbearing influence leads to overstaffing and affects labour productivity. Therefore this result is consistent with the view of Gassner et al (2007).

Zhang et al. (2008) found the joint impact of market-oriented reform with privatization and/or regulation to be stronger than the individual effects. Although our results show regulation, competition and unbundling (which is positive and significantly improve the quality of labour productivity in the region). Thus it is worth noting that the depth the commitment of government are, the more likely a country is to obtain a better off performance of the indicators. However, there is no 'standard' reform model<sup>87</sup> implemented in any of the observed countries in the region save one. Instead, a hybrid power sector has emerged. However, competition has a greater effect than regulation and unbundling, leading to statistical significance and a positive correlation with an increase in electricity generation per employee.

The log of GDP per capita was not significant, suggesting decreasing returns in the productivity of labour in the power sector. Although most African countries experienced recent rapid economic growth of 4.5% in 2013, which is projected to reach 5.1% by 2016 - (World Bank 2014), the growth rate has not done much in terms of enhancing the efficiency of the employee in the power sector. The population and manufacturing output (logged) was statistically significant and positively associated with an increase in labour productivity. In

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<sup>87</sup> In Uganda there is vertical unbundling, privatization, wholesale and retail competition and an functional independent regulator

other words, an increase in the working age population of the region leads to an improvement in labour productivity.

#### 4.10.4 Generation Capacity Utilization

Table 4.5 (Columns 7 and 8) reports the outcome of Model 4 estimation results. This shows that three of the four reform variables are statistically significant and positively associated with an increase in generation capacity utilization. Privatization on its own led to an increase in generation capacity utilization in the model. In other words, the greater the degree of privatization, the greater the capacity utilization of the generating plants. Also, a 100 percent increase in regulatory reform leads to an increase in the rate of capacity utilization (*i.e. a movement to regulation from a position of no regulation*) by 11 percent in generation capacity utilization.

In addition, the introduction of competition in the power generation sector leads to an increase in capacity utilization. But here, unbundling was insignificant and negatively associated with an increase in generation capacity generation. This is because the majority of power generation utilities in the African region are still vertically integrated.

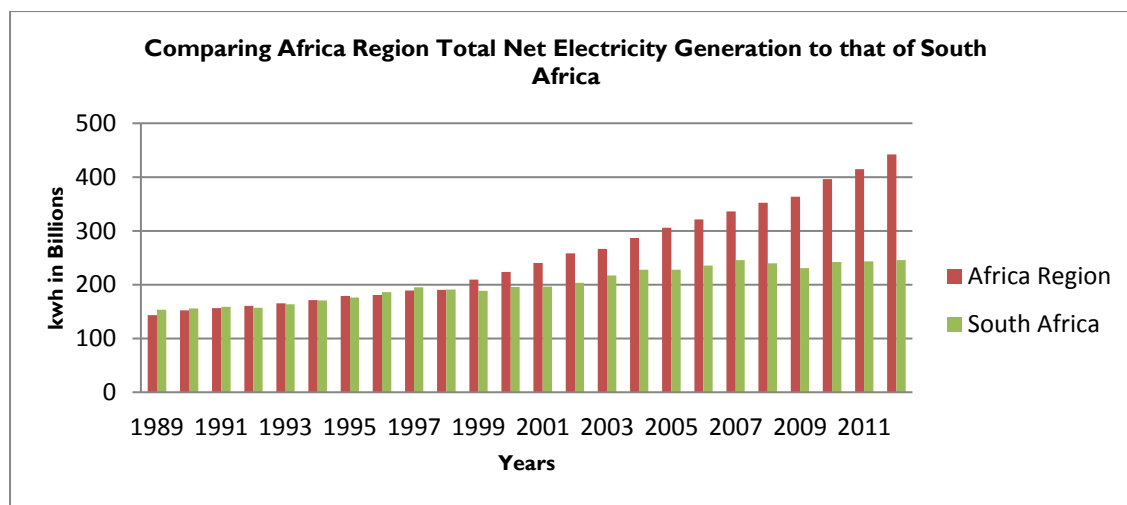
The product of regulation and privatization was significant at the 10% level and positively correlated with an increase in generating capacity utilization. Likewise, regulation combined with unbundling (RU) is statistically significant but negatively correlated with generation capacity utilization. While, the combination of privatization and competition (PC) are statistically significant, this variable is negatively associated with an increase in generation/capacity utilization. The negative sign can be explained by the fact that the majority of the electricity generation sector in the region still consists of vertically integrated state-owned companies.

In addition, we obtained an unexpected sign from the IPPs, which was significant, but negatively associated with an improved utilization rate. The log of GDP per capita was not statistically significant. The deficiencies of the region's power sector are affecting plant utilization. This can be attributed to the use of old or outdated plants whose operating life is coming to an end and also due to an increase in conflicts in the region, for example in the case of Angola, Rwanda, Cote d'Ivoire and DR Congo.

#### 4.11 Sensitivity Analyses

It is common practice in empirical studies to conduct a ‘robustness check’ to examine how regression coefficients behave when the regression specification is modified by adding or removing regressors. As the accuracy of the results in Table 4.5 depends heavily on parameter values, we have therefore tested the sensitivity of our result by removing the Republic of South Africa from the data, given its dominance in generation terms. Our hypothesis is that if the coefficients do not change significantly then we take it to be evidence that these coefficients are “robust”<sup>88</sup>(Lu and White, 2014).

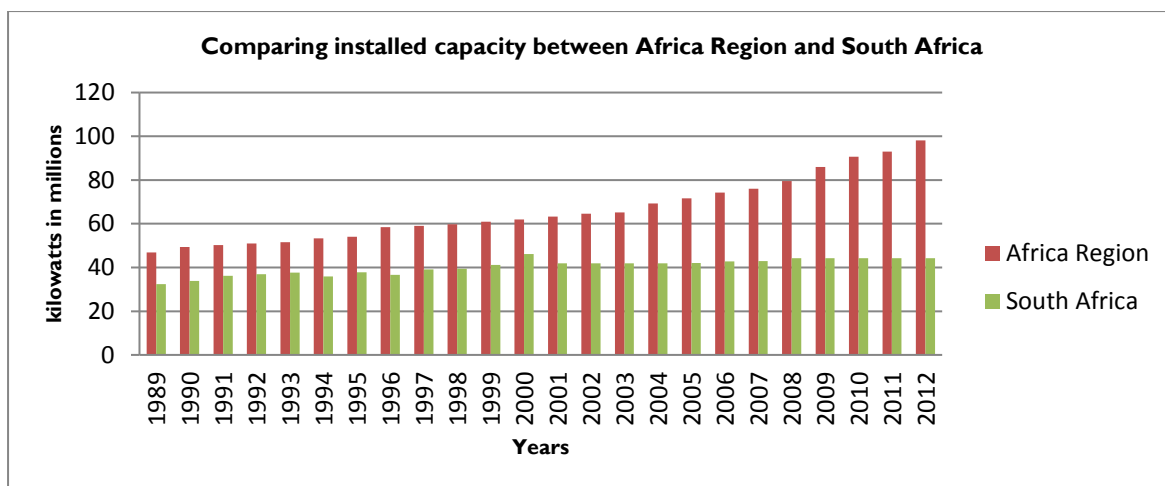
Figures 4.6 and 4.7 show the importance of the Republic of South Africa to the region in terms of electricity generation and installed capacity. Figure 4.6 shows that from 1989 to 1991, South Africa total net electricity generation is higher than that of the entire region. More generally, South Africa alone contributes up to 40 percent of the total electricity generation in the region.



**Figure 4.6:** Comparing Africa Region Total Net Electricity Generation to that of South Africa

Figure 4.7 shows the installed capacity of the entire African region compared to that of South Africa. South Africa is again the top-ranked country in the region with the highest installed electricity capacity.

<sup>88</sup> The word “robust” in this content should not be confused with the concept of robustness in the statistics literature, which refers to the insensitivity to covariate selection, typically extreme in some way. What we refer to here is the degree of insensitivity of an estimator to adding or removing sample observations.



**Figure 4.7:** Comparing installed capacity between Africa Region and South Africa

#### 4.11.1 The Importance of the Republic of South Africa in the Region

We examined whether the importance of the Republic of South Africa to the region was distorting our results by excluding it from the data. The detailed results, as presented in Table 4.6, revealed only a small variation in the interaction effect model in electricity generation installed capacity, labour productivity and capacity utilization. Our estimation coefficients do not change much, therefore we conclude that these coefficients are robust.

The power sector reform in the Republic of South Africa in the 1990s is peculiar to its history and the transformation of decades of apartheid repression to a democratic setting. The energy policy white paper of 1998 gave expression to this policy shift and called for a short – term solution to deal with the huge backlog of the disenfranchised populace who remained unconnected to the national grid. For instance, a World Bank report on South Africa (OECD Economic Surveys on South Africa 2013) urged the state-owned power utility giant (Eskom) to build more power plants to meet the demands of the populace in South Africa. That shortcoming had been evident in 2006 when South Africa witnessed a shortage in the power supply which spilt over to the neighbouring countries of Zambia, Namibia, and Zimbabwe.

One way forward lies in building new flexible power stations that will run on natural gas or heavy fuel oil as this will help the system cope with the variability in demand in the region. Equation 4.4 shows that random effects model is preferred to fixed effects reflecting that market-oriented reform on each country varies depending on the commitment of the government.

Table 4.6 presents the re-estimated model having dropped the Republic of South Africa from the model.



Table 4.6: Estimation Results without Republic of South Africa

Table 4.6: Estimation Results without Republic of South Africa								
Dependent Variables	Electricity net generation per capita (loggenpcap)		Installed electricity generation capacity per capita (Ingencapt)		Electricity generation per employee (Ingenemp)		Generation Utilization (Ingenutiliz)	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Explanatory Variables	Equ. (4.3)	(4.4)	Equ. (4.3)	(4.4)	Equ. (4.3)	(4.4)	Equ. (4.3)	(4.4)
R	0.136* (0.053)	0.096 (0.070)	0.032 (0.029)	0.007 (0.029)	-0.027 (0.128)	0.002*** (0.457)	0.113** (0.469)	0.011** (0.060)
P	0.0007* (0.0004)	-0.0001 (0.0006)	-0.0002 (0.0002)	-0.0002 (0.0002)	0.002 (0.001)	0.001 (0.001)	0.001 (0.0003)	0.003** (0.001)
CM	0.004*** (0.001)	0.003* (0.002)	-0.0002 (0.0007)	0.002* (0.001)	-0.003 (0.003)	-0.003 (0.005)	0.002 (0.001)	0.004*** (0.002)
U	-0.179*** (0.059)	-0.015 (0.093)	0.131*** (0.034)	0.323** (0.089)	0.101 (0.151)	0.085 (0.230)	-0.236*** (0.055)	-0.119 (0.083)
IPP	-0.0192 (0.0712)	dropped	0.094** (0.038)	0.086** (0.038)	0.117 (0.169)	0.092 0.168	-0.085 (0.062)	-0.112** (0.063)
ELAW	-0.063 (0.065)	-0.057 (0.051)	-0.005 (0.035)	-0.004 (0.036)	-0.351** (0.160)	-0.302** (0.156)	-0.025 (0.058)	-0.033 (0.059)
LNGENCOST	-0.027 (0.034)	-0.0164 (0.034)	0.016 (0.017)	0.019 (0.018)	0.176* (0.079)	0.130* (0.078)	-0.050* (0.029)	-0.046 (0.029)
LNGDP	0.630*** (0.086)	0.663*** (0.087)	0.579*** (0.473)	0.568*** (0.048)	-0.266 (0.211)	0.027 (0.209)	0.026 (0.078)	0.024 (0.078)
LNINDUPUT	0.030 (0.034)	0.050 (0.034)	-0.053** (0.017)	-0.049*** (0.017)	0.143* (0.079)	0.130* (0.078)	0.114*** (0.029)	0.127*** (0.029)
RP		0.002** (0.001)						0.001 (0.0007)
RU		-0.844** (0.270)				-2.934*** (0.500)		-0.176** (0.088)
RPU		0.006** (0.003)						
PCM		-4.765** (1.935)						-4.585** (1.671)
CMU		dropped		-0.003*** (0.001)				
RCM		0.008*** (0.003)				-0.037*** (0.008)		
RCMU						0.048*** (0.007)		
Adjusted R-squared	0.90	0.90	0.97	0.97	0.76	0.78	0.42	0.47
D-W test	0.21	0.24	0.40	0.41	0.61	0.63	0.25	0.26
Preferred Model	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Random Effect
Number of Obs	696		696		696		696	

#### 4.12. Discussion

The results obtained in this study complement the earlier research in this field, such as Bortolotti et al. (1998); Pollitt (1997); Faye (2001); Cubbin and Stern (2006); Zhang et al (2008); Vagliasindi and Besant-jones (2013). We found that in the absence of an independent regulator and IPPs, it will be difficult to privatize or introduce competition in the electricity generation market. Our results contradict our hypothesis that the establishment of impartial regulators is the key driver of the electricity generation performance. Rather, we found that only when these reform variables co-exist in an electricity market is there a significant impact on power generation performance.

Our findings, which are consistent with the views of Zhang et al (2008) and Cubbin and Stern (2006), found that whenever regulations combine with privatization it leads to an increase in total net electricity generation per capita. As such, our results also correspond to that of Sen and Jamasb (2012) who found that vertical unbundling of integrated power utilities leads to an increase in installed capacity.

As expected, privatization is a key indicator increasing total net electricity generation and generation capacity utilization. This was not surprising in a developing region like Africa, which lacks a strong institutional framework and is struggling with electricity market reform (when compared to western European, Nordic, and North America countries that have well-organised capital markets and strong regulatory bodies to regulate the activities of the private sectors in the industry).

In effect, the estimated model shows that the actual output of electricity generation compared to the level of installed capacity increases with an increase in private –owned capacities (P) and the presence of an impartial regulator (R). In addition, our finding suggests that the presence of a regulatory framework in the power generation industry promotes labour productivity.

It is interesting to note that, in a competitive environment, where privatized companies operate under an independent regulator, there tends to be an improvement in the generation capacity utilization rate.

### 4.13 Conclusion

It has generally been found empirically that the way to increase efficiency, electricity generation, labour productivity, and power generation capacity utilization in the electricity market is through restructuring vertically integrated structures to make them more competitive (Chen *et al.* 2013).

Among many developing countries that embarked on, or are at the early stage of power sector market restructuring or reforms, the main objective has been to attract investors to expand network grids, increase capacity building and to be more efficient and productive.

Reviewing our empirical findings in relation to our first hypothesis, we found there is no significant evidence that deregulation leads to an increase in total net electricity generation and installed capacity, but was significant and positively correlated with an improvement in labour productivity and an increase in generation capacity utilization rate. However, when considering the interaction effect, we found that when de-regulation and privatization take place it leads to an increase in total net electricity generation per capita. It is important to note that in restructuring power generation, one reform is not sufficient to bring about the desired outcome. Rather, developing countries have to design a mechanism where more than one reform variable is introduced in the electricity market.

We did find (hypothesis 2) that privatization on its own leads to an increase in total net electricity generation per capita and capacity utilization, but has less effect on installed capacity and labour productivity. Considering the interaction effect model, we found privatization to be statistically significant and positively associated with an increase in total net electricity generation per capita, and an improved capacity utilization rate. Meanwhile, it is negatively correlated with electricity generation and capacity utilization when combined with competition. Nevertheless, privatization has been a key reform in African countries market-oriented reforms. In general, it is important to note that the outcome of privatization of the power generation performance indicators shows that, privatization is insufficient to lead increases in the sector, so it is pertinent to combine other reforms indices.

Hypothesis 3 states that competition is the stimulus that enhances the performance of the sector. Our results showed competition is crucial to an increase in total net electricity generation, installed capacity and generating capacity utilization. Also, we found that when competition interacts with other reform variables, this contributes to an increase in power generation and the expansion of installed capacities. Although labour productivity and

capacity utilization were negatively correlated, both were statistically significant when implemented with privatization in electricity generation and generation capacity utilization, or with unbundling in installed capacity. Remarkably, competition in the power generation sector leads to an increase in total electricity generation, but not in labour productivity.

Lastly, vertical unbundling (hypothesis 4) is positively and statistically associated with better performance in installed electricity capacity. However, unbundling had an unexpected negative sign in regard to total net electricity generation and generation/capacity utilization, and a positive sign associated with labour productivity. When implemented with regulation, unbundling is significant, but is negatively correlated with electricity generation and also labour productivity. However, vertical unbundling in the African region is low and is only significant when it co-exists with regulation and competition in the instance of labour productivity.

Finally, power sector reform outcomes in the region reflect where countries amended electricity law to attract independent power producers (IPPs), corporatisation of service provision, and the creation of new institutions such as a regulatory authority to support reform activities. While there is no strong commitment to fully embark on privatization and unbundling, as the government prefers to engage in public-private partnership. This system promotes a hybrid structure where the state-owned vertically integrated power companies still dominated as act as a single buyer.

## Chapter 5

### **Measuring technical efficiency in African countries electricity distribution companies: a stochastic input distance function approach.**

#### **5.1 Introduction**

Governments of various African countries have embarked on restructuring their electricity markets for the past three decades, albeit with different levels of implementation among the countries in the region. Thus, while the problems confounding the sector are diverse and depend on each country, most analysts tend to focus on two key areas- improvements in the quality of service and the efficiency of the distribution utility companies in each country. A study into the electricity distribution sector presents an ideal example of how market-oriented reform is implemented in a regulated industry. Historically, the focus of the early researchers into electricity market reform was mostly in the power generation and retail supply sectors.

Even though there is no single reform model applicable to all the countries in the region, market-oriented reform generally aims to transform the vertically integrated state-owned monopolistic enterprises into unbundled and competitive entities owned or partially owned by the private sector or through public-private participation (PPP).

The rate of return has been the dominant method used in analysing utility firms' performance for decades now. Though it comes with deadweight welfare losses because of monopoly pricing, it provides an incentive for regulated companies to minimise costs. Early regulators have adopted this approach based on the work of Crew and Kleindorfer (1987), Laffont and Tirole (1993), Armstrong et al. (1994), and Sappington (1994).

There is a need to point out the potential conflict inherent between using incentive regulation and improving the quality of service in the industry. Incentive regulation does, to some extent, lead to a reduction in the quality of service and this results in a reduction in the socio-economic optimum as identified by Spence (1975). Incentive regulation can be classified under different forms, the most commonly used are Price-cap and Yardstick regulation (Benchmarking).

Price-cap methods require the utility's prices to be regulated in accordance with a general price index such as the consumer price index minus X, sometimes referred to as CPI-X. The X-factor denotes the reduction in real cost the utility firm aims to achieve. Thus, if the firm sets its cost reduction greater than the regulator's targeted price, it keeps the remainder and earns an abnormal profit, but if the firm chooses not to reduce the price (to less than the target price), then a price-cap is introduced. The problem associated with this method is the difficulty in setting the optimal X-value.

Yardstick regulation theory, as developed by Shleifer (1985), emphasised benchmarking techniques as part of the regulation evaluation. This approach was based on parametric and non-parametric methods, namely Stochastic Frontier Analysis (SFA), Corrected Ordinary Least Squares (COLS), Data Envelopment Analysis (DEA), and Free Disposal Hull (FDH) respectively (Jamash and Pollitt, 2001). Assessing the efficiency level of firms has played a vital role in measuring their performance, especially in a regulated sector characterized by natural monopoly, vertical integration and/or public ownership (such as electricity transmission and distribution) [Latruffe, *et.al* 2004]. Estimating a production/cost function appears to be a natural framework for modeling single-output production processes, but distance functions are more comprehensive for modelling multiple –output and multiple input production functions.

Studies (Giannakis *et al.*, 2005; Growitsch *et al.*, 2009; Yang and Lu., 2006) have argued that for effective evaluation of efficiency in the electricity distribution industry the use of incentive regulation and benchmarking techniques need to be incorporated into the system of analysis. Therefore, benchmarking is an essential approach in evaluating policy frameworks, efficiency improvements and also in comparing firms/companies performance outcomes in relation to best practice. Similarly, Forsund and Edvardsen (2003), Growitsch (2009), and Cullmann and Hirschhausen (2008) proposed the use of benchmarking in evaluating performance in the electricity distribution sector.

Over the years, countries such as Australia, the Netherlands, the Nordic countries and the United Kingdom have adopted the benchmarking approach. The approach involves the comparison of firms and their relative efficiency scores, not based on the geographical horizon, but on cross-country analysis. The problem associated with this approach is that it assumes that electricity distribution utilities operating in the same region can be directly be compared with another or, if not, their performance could be measured by introducing non-

discretionary variables that will capture the factors that may affect the utility performance, but are beyond their control (Estache *et al.* 2004). Such factors include the environment, institutional structure, geographical and exogenous factors, all of which affect the cost and performance level of electricity distribution utilities.

There are two contrasting views in terms of measuring efficiency improvement in the literature, concerning the way the environment should be treated. The first method treats environmental factors as influencing the production technology employed, so it is important to include such factors in the production function as regressors (Good *et al.* 1993). The second method views environmental factors as affecting the technical efficiency of the utility firms (as opposed to the production technology), and so these factors are included in modelling the source of inefficiency in the model (Battese and Coelli, 1995). While non-discretionary factors such as population density (customer density), peak load and customer satisfaction ratio should also be taken into consideration, there is disagreement as to what extent some of these factors impact on the efficiency level of power distribution utilities. Growitsch *et al.* (2010) argued that, in the long run, utility firms adjust (at least to some extent) in their operating environment, and so non-discretionary factors do have a long – term impact on their performance level and, as a result, witness diminishing returns in their efficiency scores.

The main purpose of this chapter is to estimate and compare the (mean) efficiency of electricity distribution utilities in 16 African countries using a stochastic input distance function.

In particular, we focus on what determines the sources of technical inefficiency and the impact exogenous factors such as *Customer Density*, and *Peak load* have on the performance of the electric distribution utilities. We also examine how electricity distribution utilities in the African region seek to meet the rapidly growing electricity demand while fulfilling regulatory requirements and managing ageing assets effectively. We use annual data on inputs, outputs and exogenous factors to construct panel data for 16 countries covering 235 electricity distribution companies over the period 2000 to 2013. Specifically, this study seeks to answer four key questions:

- (i). what is the effect of exogenous factors (*such as customer density and peak load*) on the distribution companies' efficiency level?
- (ii). How do electricity distribution companies behave when the quality of service is incorporated into the EDISCOs production function?

(iii). Have market-oriented reforms (i.e. *privatisation, competition, regulation and unbundling*) improved the efficiency level of the EDISCOs in the region?

(iv). Do countries with one utility company have systematically lower power distribution efficiency scores than others who possess many utility companies?

This chapter is organised into the following sections: In section 5.2 we briefly summarise African electricity market reform as it has affected distribution networks, focusing on the three largest electricity distribution networks in the region. Section 5.3 contains the empirical literature review. Section 5.4 deals with the statistical approaches towards measuring efficiency, distinguishing between parametric and non-parametric approaches. Section 5.5 justifies the technique/approach selected. Section 5.6 presents the model specification. Section 5.7 shows the dataset, choice of variables and variable description. In section 5.8, the methodology, which is employed, is outlined. Section 5.9 details the hypotheses which are to be tested. Section 5.10 discusses the empirical results, and lastly Section 5.11 draws the conclusion.

## 5.2 The African Electricity Reform and Distribution Networks

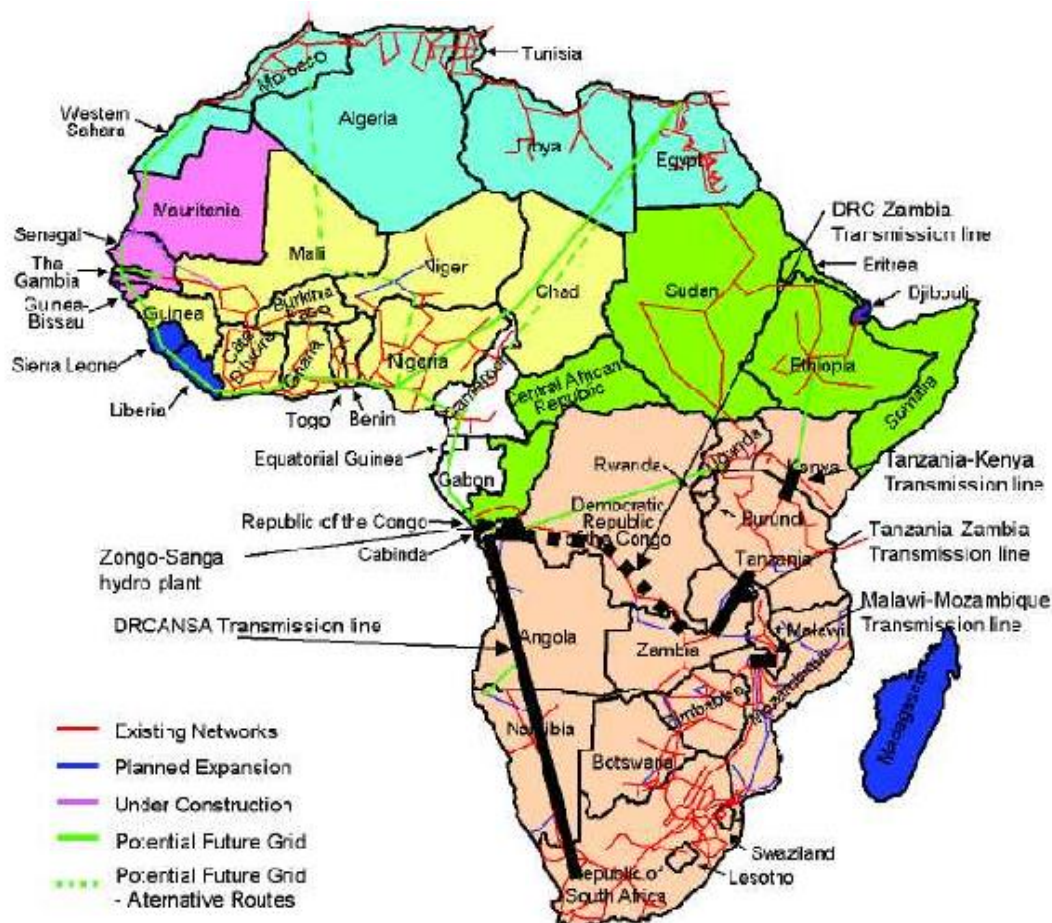
To examine the value chain of the electricity market, it is pertinent to differentiate between the various segments that make up the industry, namely electricity generation, electricity transmission, electricity distribution and, sometimes, retail supply. Electricity distribution grids take power from the high voltage transmission lines and lower it through transformers before distributing to customers (i.e. industrial, commercial and residential households). However, due to the nature of the industry, it enjoys a natural monopoly status. The sector is also one of the most politicised, this being due to service pricing and security of supply. Consequently, many African countries have established a regulator to monitor activities, and to avoid the abuse of monopoly power and the exploitation of customers. Therefore, African regulators faced the challenge of determining the optimal way to set prices and to provide incentives for the distributors (to improve their services and enhance their efficiency). Across the African countries, electricity networks are managed in different ways (see figure 5.1) although, over the last decades, almost all the countries in the region have come to belong to a regional power integration pool<sup>89</sup>.

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<sup>89</sup> Central Africa Power pool (CAPP), Eastern Africa Power pool (EAPP), North Africa power pool (NAPP), Southern Africa Power pool (SAPP) and Western Power pool.



This section focuses on the cases of the Republic of South Africa, Egypt, and Nigeria, the top three in terms of the distribution network in the region (*see figure 5.2*). Only these three countries had distribution networks over 50,000 km in 2013. In recent years, the governments of these countries have implemented market-oriented reform aimed at increasing the private-sector role in their electricity distribution sector.

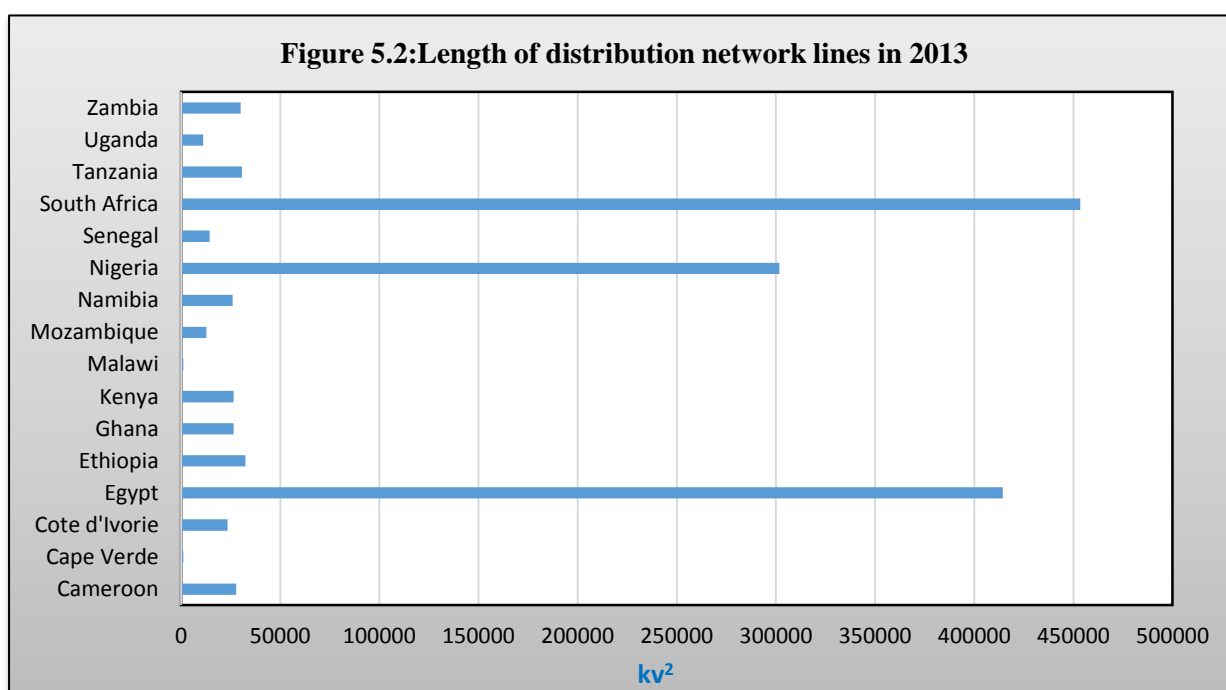


**Figure 5.1:** Map of Regional power distribution lines in Africa Region  
*Source:* IEA – Africa Energy Outlook (2014)

### 5.2.1 Republic of South Africa

South Africa is by far the biggest electricity producer and distributor in the region. In 1992, the government of the Republic of South Africa established a committee to oversee the transformation of its electricity supply industry (ESI) and produced a white paper on the way forward in the industry. In 1996, a national electricity regulatory body was established to

monitor the activities of the different segments that make up the industry and in 2004 the Electricity Distribution Industry (EDI) holding company was set up to implement the recommendation of the committee. The white paper had advocated restructuring the distribution sector into six regional electricity distributors (REDs)<sup>90</sup> and reducing the number of municipalities involved in electricity distribution. The proposed restructuring of the electricity distribution industry (EDI) into REDs did not pass through parliament however, as local municipalities were opposed or outrightly hostile to restructuring due to a perceived loss in their revenues (Kessides et al, 2007). In 2010, the EDI holding company was transferred to the Department of Energy to manage and two years later, in 2012, the government of South Africa set up a Presidential Committee to review the EDI framework and come up with a more holistic approach on the way forward<sup>91</sup>.



**Figure 5.2:** Length of distribution network lines in 2013

**Source:** Author's construction based on data from various countries electricity companies' annual report and World Bank Development indicators database.

Thus, electricity distribution is currently shared between the vertically integrated state-owned utility Eskom and 187 municipalities licensed by the National Energy Regulator of South Africa (NERSA). The local municipal distribution companies purchase all their power from Eskom and then distribute it to residential consumers, while Eskom distributes power to large

<sup>90</sup> The first Regional Electricity Distributor was established in the Republic of South Africa in 2005, but only existed on paper.

<sup>91</sup> At the time of writing, no further reform has been undertaken in the industry

industries, mines, and big farms. The state-owned enterprise Eskom is a public entity, which is subjected to the Public Finance Management Act (PFMA), while the municipal electricity distributors are under the directive of the Municipal System Act (MSA) and the Municipal Finance Management Act (MFMA) (Gaunt 2008).

### **5.2.2. The Arab Republic of Egypt**

The electricity distribution utilities in Egypt are owned and operated by nine electricity distribution companies<sup>92</sup>, under the supervision of a regulator, the Egyptian Electricity Holding Company (EEHC). The EEA Act of 2000 established the EEHC with nine distribution companies established in 2004. The electricity distribution companies in Egypt have increased the power supply, the residential power connection rate growing at an average of 4 percent each year. In 2012, 99.7 percent of the population had access to electricity, with a peak demand of 27000 MW, and the power outage rate was reduced to its lowest in the last 12 years (2000 – 2012). The percentage of transformer failure per year has also fallen substantially (by 40 percent) from 2000 and 2012 (EEHC 2013/14; Abdelfatah *et al.* 2013; and Vagliasindi and Besant-Jones 2013).

Electricity distribution in Egypt is characterised by different voltages; medium level (which is for heavy industries) and lower voltage levels (meant for commercial and residential customers). In 2002, the medium-voltage distribution network extended to 113,399km while the low-voltage distribution network was 195,281. By 2014, the medium distribution network voltage had expanded by 33 per cent to 169,183km and the low distribution voltage to 256,416 km (EEHC 2013/14 Annual Report). Thus, Egypt ranked as the second largest electricity producer and distributor in the region after the Republic of South Africa.

### **5.2.3. Nigeria (Federal Republic)**

In the case of Nigeria, privatisation of the sector started in 2005 but was not completed until 2013, following the sale of six generation companies and eleven distribution companies<sup>93</sup> to private sector companies. The government retained the role of regulator and grid operator, marking the beginning of a new era in the Nigerian distribution network. However, privatisation of the sector is yet to achieve a desirable result as there has been an increase in

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<sup>92</sup> Alexandria, Canal, El Behera, Middle Egypt, North Cairo, North Delta, South Cairo, South Delta, and upper Egypt

<sup>93</sup> Abuja Disco, Benin Disco, Enugu Disco, EKO Disco, Ibadan Disco, Ikeja Disco, Kaduna Disco, Kano Disco, Jos Disco, Port-Harcourt (PH Disco) and Yola Disco.

the number of outages (Nigerian Energy Support Programme, 2015). The length of the electricity distribution network in Nigeria comprises of 23,753km 33kv lines (medium voltage), 19,226km 11kv lines (low voltage), and 679km 33/11kv sub-stations (for industrial users).

While the majority of countries in the study are dominated by vertically integrated state-owned companies, the number of electricity distribution firms varies widely by country. The Republic of South Africa has the highest number of distribution companies (187 municipal distributors and a state-owned utility – EKOM), followed by Nigeria with eleven regional distribution companies. Egypt and Cape Verde ranked third in the table with nine distribution companies each, Namibia has four, Cameroon with three, Ghana and Zambia have two each, while the rest of the countries possess a sole distribution company.

Table 5.1 shows that Egypt has the highest population with access to electricity (99.7 percent), followed by the Republic of South Africa with 85 percent, and Cape Verde with 71 percent. The country with the lowest access is Malawi, with only 10 percent of her population having access to electricity, followed by Tanzania with 15 percent and Uganda ranked third with only 18 percent of the population with access to electricity.

**Table 5.1: Electricity Distribution Sector in selected African Countries, (2013)**

Country	Operator in distribution segment	Number of Discos	Private Sector Participation	Electricity access rate (%2012)
Cameroon	3 Interconnected Network	3	Yes	54
Cape Verde	9 regional distributors	9	Yes	<b>71</b>
Cote d'Ivoire	CIE	1	Yes	56
Egypt	9 Regional Distribution companies	9	Yes	<b>99.7</b>
Ethiopia	Ethiopian Electric Utility (EEU)	1	Yes(Indian Private Company)	27
Ghana	ECG and NEDCO	2	No	64
Kenya	Kenya Power & Lighting Company Ltd (KPLC)	1	Yes	23
Malawi	ESCOM	1	Yes (Management Contract)	<b>10</b>
Mozambique	EDM	1	Yes (Management contract)	20
Namibia	CENORED, Erongo RED, NORED, and Southern RED	4	Yes	47
Nigeria	11 regional electricity distribution companies	11	Yes	56
Senegal	SENELEC	1	Yes	57
South Africa	187 Municipal electricity distributors	187	No	<b>85</b>
Tanzania	TANESCO	1	Yes	<b>15</b>
Uganda	Uganda Electricity Distribution company ltd (UEDCL)	1	Yes	18
Zambia	CAPC and ZESCO	2	Yes	22
Total		235		

### 5.3. Empirical Literature Review

Resende (2002) applied the non-parametric (DEA) technique in assessing the relative efficiency of Brazilian electricity distribution companies. The study identified the significance of, and shortcomings with, the implementation of yardstick regulation in the industry. Although results indicated that most of the distribution firms in Brazil were inefficient, nevertheless he concluded that a yardstick mechanism is an appropriate tool in measuring productive efficiency.

The study by Chien *et al.* (2003) used a DEA method to assess the relative efficiencies of seventeen electricity distribution district service centres in the Taiwan Power Company (TPC). Using three output variables (the total number of customers, the size of the distribution network, and transformer capacity) and two inputs (the total number of staff and general equipment), they found that most of the inefficient service centres presented increasing returns to scale. This led them to recommend a restructuring of the district service centres, through the merging of the poor-performing districts into the nearest efficient ones.

Filippini *et al.* (2004) examined Slovenian electricity distribution companies using a stochastic frontier approach for the period of (1991–2000). Their findings indicated inefficiency, with distribution utilities not achieving the targeted minimum efficient scale. They concluded that the Slovenian regulatory authority should consider merging the inefficient and smaller distribution utilities with efficient larger distributors in order to minimise cost and enhance productive efficiency, a recommendation that corresponds to that of Chien *et al.* (2003).

Lavado (2004) examined the efficiency level of the electricity cooperatives (ECs) in the Philippines using parametric and non-parametric approaches. In the study, the efficiency score of each distributor was ranked and compared to distributor benchmark checks. The parametric SFA results indicated that the average EC's performance was 34% away from the targeted frontier, while the non-parametric DEA estimation showed a higher score of 42%.

Von Hirschhausen *et al.* (2006) computed efficiency scores of electricity utility networks in Germany using both parametric and non-parametric (*SFA and DEA*) approaches. Their findings (under both approaches) showed that the East German utility exhibited a higher level of average efficiency than their West German counterparts did. Their findings also indicated low returns to scale of the companies, indicating that only a small number of distribution

companies had a significant cost disadvantage. Customer density was found to be a significant factor that influenced the efficiency score of the distributors, while grid composition did not have a significant impact. Finally, they suggested the quality of service be included in future studies as it will be informative for policy purposes, although this would require a substantial effort in terms of harmonising data collection and treatment.

Bagdadioglu et al. (2007) employed DEA approach to examine the impact of merging electricity distribution companies on its efficiency. Their result suggests the mergers significantly would be able to improve the efficiency level of the distribution companies by reducing the average quantity of inputs used by 16 %.

Kopsakangas-Savolainen and Svento (2008) analysed the cost-effectiveness of Finnish electricity distribution companies. They conducted several estimations in order to select the preferred model, the tested models being based on Cobb–Douglas and Translog specifications. Their results show that the distributors are relatively inefficient in expenditure terms. They recommended reducing operation costs by merging low capacity firms with average size firms with high load factors. In conclusion, they suggested that all firms with unused capacity should seek to improve their cost-effectiveness rather than seeking to increase their average distributed volumes.

Jamasb and Pollitt (2008) evaluated the regulation of the electricity distribution industry in Sweden using the Network Performance Assessment Model “NPAM”<sup>94</sup>. They compared the difference between NPAM and frontier benchmarking methods, and found that the former is good in identifying underperforming firms. These could then be subjected to scrutiny by the regulator in order to find the source of the inefficiency and to seek ways to remove it. They concluded by pointing out the NPAM model could not allow for innovation by actual firms in the industry, and so frustrates moves to promote the long –run objective of technical change, which is needed in the industry. In addition, the NPA Model is not capable of identifying and reflecting the dynamic and complex nature of the real firms in the industry.

Growitsch *et al* (2010) examined the effect of environmental factors<sup>95</sup> on the efficiency of Norwegian electricity distribution companies. The study investigated 128 Norwegian

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<sup>94</sup> NPAM is the reference firm model developed by the Swedish energy regulatory body (EMI) for measuring and monitoring the performance of the Swedish electricity distribution companies.

<sup>95</sup> Environmental factors can be considered to be beyond the control of the utility companies. There are two types of environmental factor: observable and unobservable. The observable ones are the factors they could identify, while the unobservable ones are the factors they could not identify.

electricity distribution utilities for a four-year period (2001-2004). They utilized data on 100 geographic and weather variables to identify the source of inefficiency in the industry while controlling for the effect of observable and unobserved heterogeneity in the model. In their estimation, they employed factor analysis techniques so as to reduce the influence of environmental factors, splitting these factors into different composite variables to avoid the problem of multicollinearity. Then they estimated a stochastic frontier model based on Battese and Celli's (1992; 1995) techniques and made use of the true fixed effects models developed by Greene (2004; 2005), with and without environmental variables (weather and geographical conditions). Their results showed some of the environmental variables had a significant effect on utility performance. However, in the fixed effects models the effects vanish.

Simaba and Haghifama (2011) applied both non-parametric (DEA) and parametric (SFA) methods to measure the technical efficiency of 41 Iranian electricity distribution companies. They found that when the quality of service provided by electricity distribution companies increased by 1 percent, there was a corresponding 0.65 percent increase in the cost of production. Variables such as peak load and service area had a positive effect on the cost of production.

Coelli *et al.* (2013) estimated the cost of improving the quality of the electricity distribution service using a multi-output (*energy supplied, number of customers and service area*), and input (*Operating cost, capital, and quality of service (bad input)*) model. In the study they incorporated environmental factors (*underground line, small town [customer density], assets age, customer growth and HV industrial capacity*) to verify the impact of environment factors on the technical efficiency of electricity distribution companies using translog technology based on a parametric input distance function (IDF) approach. They employed a panel data of 92 electricity distribution units operated by ERDF (*Electricite' de France-Re'seau Distribution*) for three years (2003–2005). In order to evaluate the cost of improving the quality of service in the industry, they introduced the number of electricity interruptions (in days) as a proxy for quality of service in the model estimation. Their result shows that SFA models obtain a higher technical efficiency score than the parametric linear programming (PLP) approach. They found in both models (SFA and PLP) that at the *first – order coefficients level*<sup>96</sup> all the variables have the expected signs and are statistically

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<sup>96</sup> Another word for First-order coefficient is the first-order elasticities



significant at the 1% level. However, when considering the *second-order coefficients*<sup>97</sup>, the squared variables - capital (CAP), the number of customers (CUST), and quality of service (NINT) are insignificant. Moreover, their finding shows that the environmental factors are statistically insignificant, except for underground lines, the average age of assets, and the year dummies for 2004 and 2005, which are statistically significant and have an effect on the electricity distribution companies' efficiency level.

Furthermore, their findings showed that it would require a 6.8%, 0.5% and 2.5% increase in operating expenditure, capital, and quality of service, respectively, to have a significant positive effect on the number of customers and service area. They concluded that for effective regulation (and to improve the quality of service in the electricity distribution industry), the regulators have to introduce explicit regulation of the quality of service. This could be done by benchmarking the regulated price with its marginal cost in order to determine the efficiency level.

Finally, Mullarkey *et al* (2015) applied a non-parametric DEA approach to determine the technical efficiency of the distribution network in Ireland. The results from the estimated parameters showed some intuitive understanding of the source of efficiency improvement in EDC in Ireland, namely merging small and less efficient EDCs with large ones would reduce the number of EDCs from 26 to 11 and increase the relative technical efficiency. It also highlighted the overall efficiency of all the electricity distribution companies in a country that has experienced an improvement in its electricity supply because of the restructuring. Their findings suggest including diagnostic parameters in the model proves to be a superior variable as such, the proposed re-organisation of EDCs recorded higher efficiency scores of up 10%, as the number of EDCs were reduced. Their result confirms that environmental factors have a significant impact on the technical efficiency level of EDCs, resulting in an increase in the efficiency level of EDCs from 83 percent to 91 percent.

There are few studies based on *cross-country analysis* on this subject matter (*see table 5.2*). Zhang and Bartels (1998) estimated efficiency scores using DEA. Focusing on three countries (Australia, New Zealand, and Sweden), they found that Australian electricity distributors were the most efficient, with average scores close to the frontier, with New Zealand following. Swedish electricity distributors had the worst efficiency score. They

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<sup>97</sup> Second-order coefficient could be referred to as the second-order elasticities. Based on theoretical expectations, the models ought to produce negative coefficients of outputs and positive coefficients of inputs.

concluded that the rate of decrease in efficiency depends largely on the number of distributors. Countries with a small number of distributors will experience a sharp decrease in efficiency levels, while countries with a large number of distributors will have a lower rate of decrease. The problem with this study is that it used data for just three inputs (*number of employees, total kilometres of distribution lines and total transformers' capacity (MVA)*) and one output (*number of customers served*). We employed multiple outputs and input data in our study in order to capture key performance variables in our analysis of technical efficiency in the electricity distribution industry in African countries.

Hattori (2002) conducted a comparative study of the technical efficiency of the United States and Japanese electricity distribution utility companies over a fifteen year period (1982 – 1997) using the SFA parametric approach. Their results showed that, after controlling for environment factor effects, Japanese electricity distribution companies (on average) are more efficient than their U.S counterparts. They also point out the need for effective regulation of the industry as there is a tendency for inefficiencies to increase over time, and also the need for technological innovation in the industry (as the annual rate of technological change has been decreasing).

Edwardsen and Forsund (2003) examined the performance of 122 electricity distributor companies in five countries (Denmark, Finland, Norway, Sweden, and Netherlands) in 1997 using DEA and Malmquist Productivity index methods. They found that Finnish electricity utilities exhibit a higher degree of productivity than other countries in the sample. They concluded by pointing out the need for the harmonization of data and the description of variables, a conclusion which corresponded to the recommendation made by Jamasb and Pollitt (2003).

Jamasb and Pollitt (2003) conducted an empirical assessment of 63 electricity distribution companies in Europe using both parametric (SFA and COLS) and non-parametric (DEA) approaches. They found a substantial difference in estimated efficiency scores among the countries, while the choice of benchmarking techniques, model specification and input and output variables influenced the efficiency scores and the rank order of the firms among the countries in the sample. They concluded by emphasising the need for regulators to establish long-term commitments to achieve set objectives. They also recommended regulators identify appropriate variables and establish standard procedures for effective data collection.

**Table 5.2:** A summary review of cross-country studies

Author(s)	Data	Inputs	Outputs	Method
Zhang and Bartels (1998)	32 electricity distribution utilities for Australia, 51 for New Zealand and 173 Swedish electric distributors	Number of employees; Total kilometres of distribution lines and Total transformers' capacity (MVA)	Total number of customers served	Non-Parametric approach (DEA) and Monte Carlo Simulation
Hattori (2002)	Two countries comparative study (U.S and Japanese) Electricity distribution utilities (1982 – 1997)	Labour, capital (MVA), Sales-residential (GWh), Sales-industrial and the number of utilities	Load factor, Customer density, Consumption per customer(MWh), and the ratio of non-residential sales	Parametric (SFA)
Jamasb and Pollit (2003)	63 electricity distribution companies in Europe	Operating expenditure, Total expenditure, Network length, Transmission & Distribution losses, non-discretionary inputs	Units delivered, number of customers and Network length	Parametric (SFA) and Non-Parametric (DEA)
Edvardsen and Forsund (2003)	122 electricity distributors in five European countries	Total operating cost, maintenance costs, distribution losses, total lines, and replacement value	Energy delivered Number of customers	DEA Malmquist index
Estache <i>et al.</i> (2004)	South America's main electricity distribution companies	Number of employees, distribution network and transformer capacity	Total sales (GWh)	Parametric (SFA) and Non-Parametric (DEA)
Hattori <i>et al.</i> (2005)	Comparative study on UK and Japan Comparative efficiency analysis of 21 electricity distribution utilities (12 for the UK, 9 for Japan)	Total expenditure	Number of customers, Electricity units delivered in megawatt-hours (MWh) Customer density and load factor	Parametric (SFA) and Non-Parametric (DEA)
Apfelbeck <i>et al.</i> (2005)	Regional electricity distribution companies in five East European countries and Germany	Number of employees and length of the electricity grid	Total sales (GWh)	Parametric (SFA) and Non-Parametric (DEA)
Estache <i>et al.</i> (2007)	Southern Africa Power Pool (SAPP)	Installed Capacity (MW) Number of workers (Labour)	Generation (GWh) Number of Sales (GWh) Number of Customers	DEA and Malmquist Productivity
Growitsch <i>et al.</i> (2009)	499 electricity distribution utilities from eight European countries	Total expenditure, Number of customer minutes lost (proxy for quality of service)	Number of customers Units of energy and Country dummy and Customer density	Parametric (SFA)
Jaunky (2013)	Data from 12 Southern Africa Power integration pool (SAPP)	Electricity supply (GWh)	Number of Employees and Installed generation capacity	Parametric (SFA) and Non-Parametric (DEA)

Estache *et al.* (2004) investigated the efficiency scores of South America's main electric distribution companies using both parametric SFA and non-parametric DEA methods. Their finding identified a weak consistency in the estimators used for the analysis. They were of the view that countries in the region should, as a matter of urgency, harmonise their regulatory database to enable international benchmarking comparisons among themselves. They identified that the operators of electricity distribution firms in the region have an information asymmetry advantage over the regulators and suggested, that through cross-country cooperation and comparative regulatory studies, regulators can gain a better insight into the operational dimensions of the industry and thereby more effectively regulate the industry.

Hattori *et al.* (2005) examined the technical efficiency of UK and Japanese electricity distribution between 1995 and 1998. They adopted parametric and non-parametric (SFA and DEA) approaches and found that UK electric distributors are closer to their efficiency frontier than their Japanese counterparts are. They also found that regional electricity distribution companies in the UK exhibit greater productivity growth than their Japanese counterparts.

Apfelbeck *et al.* (2005) studied the relative efficiency of four East European (Poland, Czech Republic, Slovakia, and Hungary) member countries. They measured and compared the relative efficiency of each country's distribution companies against a German distribution company benchmark using both DEA and SFA. Their results indicate that Polish distribution companies are inefficient, while the Czech Republic and Slovakian firms recorded the highest efficiency score in the study. They concluded that the countries in the sample needed to deepen their reform processes in the electricity distribution sector.

Estache *et al.* (2007) were the first to estimate productivity levels in the Southern African region. The study focuses on twelve Southern African electricity distribution companies. They examined the total factor productivity (TFP) of the largest operators in each of the countries from 1998 to 2005 using DEA to decompose and identify the source of change in TFP. They found there was a slight productivity growth in terms of technological improvement and the ability to reach more customers in the distribution utilities. Their results also indicated that there was no significant improvement on the technical side (there was no change in the technical efficiency level). However, they concluded that it was too early to arrive at a conclusion on the potential for improvements expected from the reform ongoing in the electricity market.

Growitsch *et al.* (2009) examined the cost of improving the quality of service in 499 electricity distribution companies in eight European countries<sup>98</sup> using a parametric (SFA) approach based on multi - inputs, outputs, and environmental factors. They estimated two basic models. The first is based on one input (*total operating expenditure*) and two output variables (*energy delivered* and the *number of the customers*) with environmental factors (*customer density and country specific dummy*) included to account for national differences among the sample countries. The second model incorporated the quality of service as an undesirable input variable (*a proxy for number of interruptions in electricity supply*) to reflect the substitutive relationship between cost and duration of outages (i.e. an efficient firm ought to reduce the number of interruptions in service delivery while increasing the electricity supply level). Their findings indicated that incorporating the quality of service into the model does not affect scale efficiency, but that service quality should be treated as an integral part of efficiency analysis and incentive regulation regimes.

Their results showed the *log of energy delivered* and *numbers of customers* are statistically significant, and have the expected a priori sign. Likewise, environmental factors such as *customer density* and *country specific dummies* had a significant influence on the technical efficiency scores. The study shows that of the eight countries examined four (Norway, Sweden, Finland, and Netherlands) had a significantly higher technical efficiency than the rest. Customer density has a significant impact on the level of the technical efficiency, as an increase in customer density leads to a rise in the efficiency of these EDCs. In addition, in a second model (with the quality of service factor included), the *log of energy delivered* and the *log of number of customers* were statistically significant, thus the input variable - *total operating expenditure* increases as both output variables increase.

Jaunky (2013) examined the divergence in the technical efficiency of electricity utilities in the Southern African Power Pool (SAPP) within the period 2003 – 2010 using both SFA and DEA approaches. The study highlighted technical efficiency in generation, transmission, and distribution of the electricity market in the SAPP region. The found the South African vertically integrated company (Eskom) to be the most efficient firm, and the Mozambique state-owned utility firm (*EDM*) to be the least efficient. The study also explored technical efficiency convergence among the 12 countries, finding that the sub-region is converging fast towards its own technical efficiency steady state. There was also a positive association

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<sup>98</sup> United Kingdom, Ireland, Netherlands, Finland, Norway, Sweden, Italy and Spain

between consumer density and technical efficiency, which explains why the governments faces a big task in connecting rural villages to the national grid.

The above studies have all used a variety of variables in estimating benchmarking models in the electricity distribution sector. However, the majority of the studies are based on a single country-specific framework, which suffers from the problem of small sample sizes and a short sample period. They are also mainly focused on European and OECD countries. In this study, we aim to extend the models from the previous studies by making use of a detailed database covering the activities of 234 electricity distribution companies in sixteen African countries over a period of thirteen years (2000 -2013). To the best of our knowledge, this study signifies the first attempt to measure the technical efficiency of electricity distribution companies in the wider African region.

#### 5.4. Statistical Approaches towards Measuring Efficiency

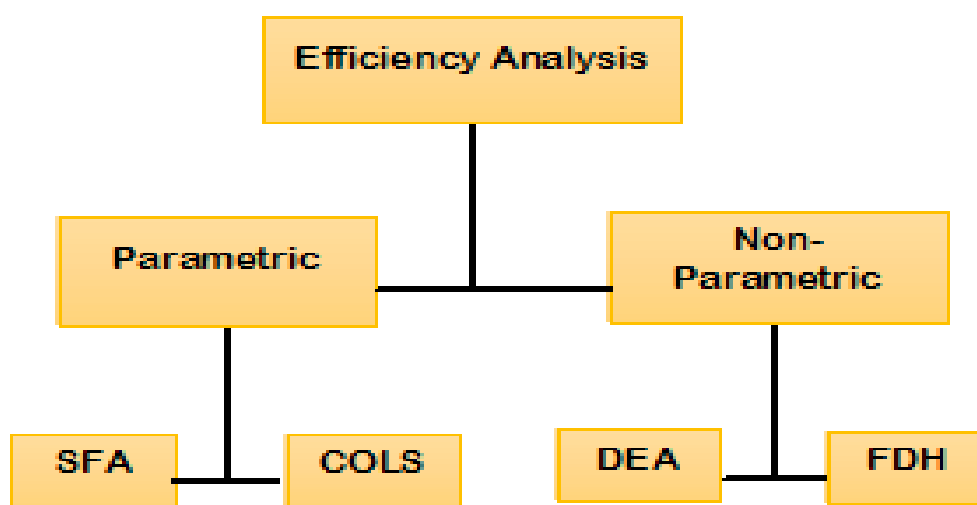
During the last three decades there has been a significant reorganisation in the African electricity market (*see Chapter three, section 3.6*). The introduction of competition in the power generation sector (*Chapter four, section 4.4*) was more successful than in the transmission and distribution sectors mainly due to the nature of the latter sectors. Most of the studies of electricity distribution networks have acknowledged that there is an element of natural monopoly inherent in electricity distribution networks. In economic theory, a natural monopoly occurs when a single firm has the required resources and manpower to produce sufficiently and efficiently the required output of the product(s) with the assumption that the long run average cost falls, as output vectors increase (i.e. the firm has increasing returns to scale) (Baumol et al 1982).  $Y^i, i = 1, \dots, m$ :

$$C(\sum_{i=1}^m Y^i) \leq \sum_{i=1}^m C(Y^i) \quad (5.1)$$

Where  $Y^i$  is the outcome vectors,  $C(Y)^i$  is cost and the global sub-additive condition for a natural monopoly.

The monopolistic characteristics of electricity distribution networks are derived from three components: i). the high degree of sunk investments in network assets (such as transformers and power lines), ii). economies of scale in electricity supply, and iii). economies of scope between customers and energy delivered in the network (Growitsch *et al*, 2009).

Empirically, there have been different methods used in estimating efficiency scores of electricity distribution companies. There are two dominant approaches commonly used in the estimation of efficiency and productivity in this field - Data Envelopment Analysis (DEA) and Stochastic Frontier Analysis (SFA), but there are also two other approaches - Free Disposal Hull (FDH) and Corrected Ordinary Least Square (COLS). DEA was first employed by Farrell (1957), and FDH, originally introduced by Deprins *et al* (1984), are non-parametric approaches. SFA, simultaneously developed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977), and COLS, as suggested by Winsten (1957) and Greene (1980), are parametric approaches (*see figure 5.3*). The non-parametric approach uses linear programming to determine firms' efficiency levels. SFA and COLS<sup>99</sup> are built upon the assumptions of econometric regression methods to estimate cost and production functions (which depend on the ex-ante specification of the functional form and the decomposition of the residual into a non-negative inefficiency term and an idiosyncratic error).



**Figure 5.3:** Efficiency frontier measurement methods

*Source:* Author's construction

#### 5.4.1. Data Envelopment Analysis

The genesis of the application of DEA in the field of economics can be traced to the work of a Cowles commission monograph, entitled *Activity Analysis of Production and Resource Allocation* (Koopmans, 1951), which identified the similarities that exist between nonnegative prices and the use of mathematical (linear programming) knowledge in solving

<sup>99</sup> One of the shortcomings of COLS is that it is mainly limited to one output in the production function estimation

the problem of optimisation. DEA is a non-parametric approach that centres on a piecewise frontier over the data, which evaluates the firms' efficiency and relative productivity. DEA is commonly used for benchmarking analysis (that is to compare each operator with the *best alternative* operator(s)).

The application of the DEA approach does not involve any assumption of a functional form relating to the variables (inputs and outputs)<sup>100</sup>. In practice, with a given set of inputs and outputs of different firms, empirically the DEA approach does not construct a functional form. Therefore, using DEA helps a researcher to avoid misidentification and misspecification of frontier technology. DEA suits analyses with a small sample size. According to Nunamaker (1985) and Raab and Lichty (2002), DEA works well with a sample size that is double, or more than the sum of, the number of input and output variables used.

#### 5.4.2 Free Disposal Hull (FDH)

The FDH approach<sup>101</sup> was initiated by Deprins, Simar and Tulkens (1984) based on mixed nonparametric mathematical programming techniques. FDH approaches are mainly used to estimate a true (but unknown) production technology for efficiency and benchmarking measurement. The only difference between DEA and FDH is that the latter allows for non-convexity<sup>102</sup> whereas the former does not.

FDH estimates non-convex production functions and compares other decision-making units by assuming there is free input – output dispersibility. It involves imposing plausible restrictions on the production process to construct a piecewise linear reference technology (or best practice frontier) on the input-output production combination. Intuitively, the FDH approach shows that a firm is inefficient if another firm uses less input in the production of similar outputs.

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<sup>100</sup> In contrast, using other analytical tools such as the econometric approach requires assumptions of a functional form (such as Cobb-Douglas or Translog).

<sup>101</sup> [Is feasible with small samples but only because it has no statistical properties](#)

<sup>102</sup> Non-convexity refers to violations of the convexity assumption (that is when convexity assumptions are violated, then most of the good properties of competitive markets will not hold) In other words, non-convexity is associated with market failures. This could also refer to a situation where a particular combination of inputs are preferred to another.



### 5.4.3. Corrected Ordinary Least Squares (COLS)

The corrected ordinary least squares estimator is a parametric method with a deterministic frontier. Winsten (1957) first suggested it. The method involves shifting the constant in the OLS estimation either upwards (for a production frontier) or downwards (for a cost frontier) as all points on the frontier either lie below or above the estimated function. Using this method ignores the possibility of exogenous shocks, measurement errors and noise (statistical) in the model. Therefore, this method is easy and simple but this simplicity in the model comes with a penalty, in that all the discrepancies are imputed to the error term, which captures the production inefficiency. COLS is also sensitive to outliers, as it tends to overestimate the efficient frontier, making the inefficiency score greater than it would otherwise be as a result (Kumbhakar *et al.* 2015).

### 5.4.4 Stochastic Frontier Analysis (SFA)

SFA is a parametric approach which makes use of econometric models in an estimation process (either as a production, cost, or profitability frontier) in analysing efficiency and/or productivity in relation to the input and output variables. This approach was developed simultaneously by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977) in estimating the technical or productive efficiency.

Estimation using this method involves two stages: (i). the frontier model is estimated by maximum likelihood. (ii). the outcomes from the first stage are used to construct measures of efficiency or inefficiency.

In estimating technical or productive efficiency/inefficiency in production frontier analysis, we assume firms are using similar production technology. Efficiency in production is measured when a firm(s) reach their production possibilities frontier (i.e. a score equal to one (1) signifies full efficiency in the production process. If the score is *less than* one (1) then it signifies inefficiency in production). There is room for firms to change input combinations in an effort to achieve best practice and full efficiency. Thus, this method allows comparison among firms based on the best practice-benchmarking standard.

### 5.5. Technique/Approach selected

One of the leading challenges involved in measuring the efficiency or inefficiency of a sector/industry, especially in a regulated industry such as a network utility industry, is clearly the need to identify appropriate indicators.

The stochastic frontier analysis was selected over COLS and the nonparametric approaches of DEA and FHD because it allows random noise to be included in the model. The second advantage of using SFA is that it is possible to control for measurement errors, omitted variables and other misspecification (which are counted as inefficiencies). Deterministic models such as DEA and COLS are also very sensitive to outliers. Moreover, because SFA is a parametric method based on regression, it is flexible enough to allow for the creation of confidence intervals for its parameters. Finally, when dealing with panel data, the SFA method has an added advantage in that it is no longer necessary to specify the distribution of the inefficiency term.

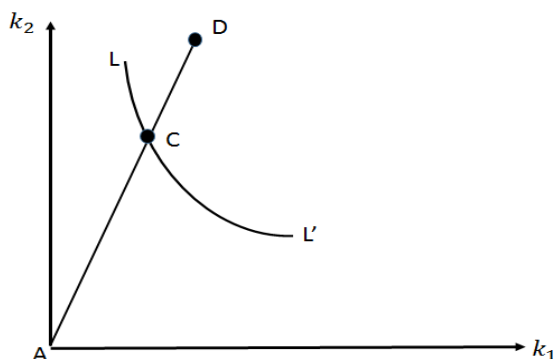
Traditionally, efficiency analysis in the electricity industry assumes that outputs are fixed (that it is the legal obligation of the EDISCOs to supply energy to all customers in its predefined service territory). Thus, EDISCOs are unable to control the amount of energy consumed (consumer demand). Therefore, since our aim is to assess the technical efficiency of these EDISCOs (under the objective of minimizing the amount of resources utilized), an input-oriented model was used.

For the purpose of this study, we employed an input distance function (IDF). The IDF is preferred for the following reasons:

- (i). Electricity distribution companies (EDISCOs) have limited control over their outputs. In the short-run, they cannot influence the number of customers, nor the amount of electricity distributed, which are independently determined due to their derived nature. In terms of their inputs, they can, however, adjust to ensure that the network has the right capacity at all times.
- (ii). The essential purpose of regulation is to cut unnecessary cost, wastage in management and the use of input resources so that EDISCOs minimise costs, are efficient and produce at the optimal level.

Figure 5.4 illustrates the input distance function, with two inputs, ( $k_1$  and  $k_2$ ), used in the production of output,  $m$ . The isoquant,  $LL'$ , is the inner boundary of the input set showing the minimum input combinations that are required to produce a given output vector. Thus

figure 5.4 shows the value of the distance function for a company (firm) producing output,  $m$ , using the available input variables combination at point D, which is equal to the ratio of AD/AC.



*Figure 5.4: The input distance function and the input combination*

## 5.6. Model Specification

Assume the production technology (frontier) is known (although that is not normally the case we could measure the distance that each data point [country Distribution Company] lies). We can calculate a number of input variables ( $x$ ) that could be used to produce a certain amount of output ( $y$ ). In principle, for each data point for the linear combination of ( $x/y$ ) we look for the best possible value of a scalar  $\rho^{103}$  such that  $(x/\rho, y)$  belongs to the same production set (feasible) bounded by the frontier, where  $\rho$  is assumed to be the technical efficiency score of an electricity distribution company. Therefore, literally, an efficient EDISCO can reduce its input by  $(1/\rho)$  and still be able to produce the same amount of output.

In reality, that is not the case as the production frontier is unknown. Instead, economists use data on a number of electricity distribution companies in the specified region to measure the distance so that the frontier fits to the data. In the case of this study, we employed the parametric technique to estimate an input distance function.

### 5.6.1 Stochastic Frontier Analysis Estimation

In the course of analysing the technical efficiency of electricity distribution utility companies in Africa, it is vital we consider the impact of exogenous factors upon the technical efficiency of the distribution companies. As electricity distribution companies do not have absolute control over these factors then these factors could affect the quality of service provided. We

<sup>103</sup>  $\rho$  is a non-negative scalar

seek to control for the impact of these exogenous factors (such as *customer density* and *peak load*) on technical efficiency. The first method involves including the factors in the production function. We assumed that differences in technology between regulation schemes for the case of M output and K inputs is specified as:

Technology:  $\mathbf{x}' = (x_1, x_K)$  is an input vector and  $\mathbf{y}' = (y_1, \dots, y_R)$  is an output vector

Assume the existence of a technology set  $T(\mathbf{x}, \mathbf{y}) = \{\mathbf{x}, \mathbf{y}: \mathbf{x} \text{ can make } \mathbf{y}\}$

Input requirement set:  $I(\mathbf{y}) = \{\mathbf{x}: \mathbf{x} \in T(\mathbf{x}, \mathbf{y}) \text{ given } \mathbf{y}\}$

Input distance function:  $DI(\mathbf{x}, \mathbf{y}) = \max \{\rho : (\rho \mathbf{x}) \in I(\mathbf{y})\}$

### Properties

1.  $D_I(\mathbf{x}, \mathbf{y}) \geq 1$
2.  $D_I(\mathbf{x}, \mathbf{y})$  is homogenous of degree +1 in  $\mathbf{x}$
3.  $D_I(\mathbf{x}, \mathbf{y})$  is increasing in  $\mathbf{x}$
4.  $D_I(\mathbf{x}, \mathbf{y})$  is decreasing in  $\mathbf{y}$

From property 1,

$$\ln D_I(\mathbf{x}, \mathbf{y}) - u = 0 \text{ for } u \geq 0 \quad (5.2)$$

From property 2,

$D_I(\tau \mathbf{x}, \mathbf{y}) = \tau D_I(\mathbf{x}, \mathbf{y})$ ; let  $\tau = 1/x_K$  and let  $x_k/x_K \equiv \tilde{x}_k$ , then

$$\ln D_I((1/x_K) \mathbf{x}, \mathbf{y}) \equiv \ln D_I(\tilde{\mathbf{x}}, \mathbf{y}) = -\ln x_K + \ln D_I(\mathbf{x}, \mathbf{y}) \quad (5.3)$$

Use result 5.3 to write:

$$-\ln x_K = \ln D_I(\tilde{\mathbf{x}}, \mathbf{y}) - \ln D_I(\mathbf{x}, \mathbf{y}) \quad (5.4)$$

Use equation (5.2) and (5.3) to write

$$-\ln x_K = \ln D_I(\tilde{\mathbf{x}}, \mathbf{y}) - u \quad (5.5)$$

In equation (5.5), make three empirical assumptions:

- i).  $\ln D_I(\tilde{\mathbf{x}}, \mathbf{y})$  can be approximated by the sum of a translog function and a symmetric iid random variable:  $\ln D_I(\tilde{\mathbf{x}}, \mathbf{y}) \approx T(\tilde{\mathbf{x}}, \mathbf{y}) + v$
- ii). The nonnegative slack variable  $u$  can be approximated by an asymmetric iid random variable
- iii). The technology shifts over time  $t$  through non-neutral technical progress

Then we obtain the estimating equation based on stochastic input distance function

The assumption is that this production technology satisfies the condition as stated in Fare and Primont (1995), where  $D_I(x, y)^{104}$  is non-decreasing, positively linearly homogeneous of degree one (1), concave in  $x$  and increasing in  $y$ .

### 5.6.2 Stochastic Input Distance Function

The IDF will take values in the range of greater than or equal to 1 if the input vector  $x$  is an element of the feasible input set,  $L(y)$ . Thus  $D_I(x, y) \geq 1$  if  $x \in L(y)$ , which implies that any electricity distribution company on the frontier of the input set will equal to unity (1). Following Kumbhakar and Lovell (2000), Coelli et al. (2003) assumed that the translog input distance function is flexible and allows for the imposition of assumptions from microeconomic theory (such as homogeneity<sup>105</sup>, symmetry and monotonicity).

The input distance function (IDF) is specified as  $D_I(X, Y) = \max\{\rho : (\frac{X}{\rho}) \in L(Y)\}$  (5.6)

where the input set  $L(Y)$  stands for the set of all input vectors  $X \in R_+^K$  that can produce outputs vector  $Y \in R_+^M$ , that is  $L(y) = \{x \in R_+^K : x \text{ can produce } y\}$  (5.7)

Therefore, having imposed homogeneity of degree 1 in inputs, we recomposed the error model in which the inefficiency term is subtracted from the composed error of production function. Equation (5.8) illustrate the translog input oriented distance function for panel data estimation based on time varying efficiency.

$$\begin{aligned}
 -\ln x_K = & \alpha_0 + \sum_{r=1}^{r=R} \alpha_r \ln y_r + \sum_{k=1}^{K-1} \beta_k \ln \tilde{x}_k + \frac{1}{2} \left[ \sum_{r=1}^{r=R} \sum_{s=1}^{s=R} \alpha_{rs} \ln y_r \ln y_s \right] + \frac{1}{2} \left[ \sum_{j=1}^{j=K-1} \sum_{k=1}^{k=K-1} \beta_{jk} \ln \tilde{x}_j \ln \tilde{x}_k \right] \\
 & + \left[ \sum_{r=1}^{r=R} \sum_{k=1}^{k=K-1} \gamma_{rk} \ln y_r \ln \tilde{x}_k \right] + \delta_1 t + \delta_2 t^2 + \sum_{r=1}^{r=R} \eta_r (\ln y_r) t + \sum_{k=1}^{k=K-1} \mu_k (\ln \tilde{x}_k) t + v - \ln D_I
 \end{aligned}
 \tag{5.8}$$

The composed error term emerges by interpreting the negative of the log of the input distance function as a measure of inefficiency:

$\varepsilon_{it} = v_{it} - \ln D_{lit} = v_{it} - u_{it}$ ,  $i = 1 \dots n, t = 1 \dots T$  with the usual stochastic frontier analysis assumptions:

$$v_{it} \sim N(0, \sigma_v^2) \quad u_{it} \sim |N(0, \sigma_u^2)|
 \tag{5.9}$$

<sup>104</sup> X and Y variables denotes input and output respectively in distance function

<sup>105</sup> Homogeneity is discussed often in microeconomic theory. A function is regarded to be of homogenous of degree n, that is if n=1. So if output is increased by 1 and all the inputs increase by the same proportion, thus we refer to it as of homogenous of degree 1.

Here the property of homogeneity of degree 1 in inputs is implicitly imposed by the use of:  $\tilde{x}_k = (x_k/x_K)$  as the typical input variable. The property of symmetry of the second order terms requires the restrictions:  $\alpha_{rs} = \alpha_{sr}$  and  $\beta_{jk} = \beta_{kj}$ .

In this chapter, a two –stage approach is used where the efficiency scores (as estimated by exponentiating the Jondrow et al. (1982) estimated conditional mean of the inefficiency components) are further regressed against the exogenous reform variables:

Thus, according to the time-varying specification of the electricity distribution companies' inefficiency, the technical efficiency of the EDISCOs  $i$  at period  $t$  could be defined as

$$EFF_i = \exp(-\hat{u}_i) \equiv \exp(-\hat{E}(u_i/\varepsilon_{it})) = \delta_0 + \sum_l \delta_l z_{lit} + w_i \quad (5.10)$$

We estimated our empirical model based on Kumbhakar *et al.*'s. (2015) written command codes procedure, using STATA 13 software.

Although, the two stage approach is biased and inefficient because Z-variables are omitted from the first stage. Also the error terms in the second stage do not comply with classical OLS assumptions since the dependent variable is generated from stage 1 where the errors are assumed not to have classical properties. This is the critique developed by Schmidt and Wang (2001) in their work published in journal of productivity analysis. However, the model can be better treated by using, for example, the Battese-Coelli (1995) conditional heteroskedasticity procedure in which the stochastic frontier analysis error assumptions are stated as in equation (5.11 and 5.12).

$$v_{it} \sim N(0, \sigma_v^2) \quad u_{it} \sim : N(\mu_{it}, \sigma_u^2) : \quad (5.11)$$

$$\text{And } \mu_{it} = \delta_0 + \sum_l \delta_l z_{lit} \quad (5.12)$$

### 5.7. Dataset, choice of variables and Variables Description

The dataset used in this study is a balanced panel dataset consisting of 224 observations from sixteen African countries with 235 distribution companies (DISCOs) for the years 2000 to 2013. The data was obtained mainly from the World Bank – Africa infrastructure database (Electricity and National data domain), electricity regulatory websites, the annual report and financial statements of each distributor in each country, the PPIAF-Public-private infrastructure advisory facility, World Bank Development Indicators, and the World Bank enterprise database. We harmonized the data to avoid measurement errors and arranged it in the appropriate format for estimation. Part of the harmonization process involved converting all the monetary values into a

single monetary unit (US\$, using 2005 as the base year) as all the sixteen countries examined in this study make use of a different currency (see table 5.3).

### 5.7.1 Choice of Variables

The selection and measurement of variables for inputs, outputs, and exogenous variables have to be restricted to the common variables the national regulators use and are in accordance with international experience in electricity distribution benchmarking.

### 5.7.2 Input variables

The input variables used in the study are *total operating expenditure* (TOPEX – monetary value), *the number of distribution transformers* (NUMTRM - physical level), and *the number of employees* (EMPLY - the sum of the permanent staff). We know that the distribution utilities in this region historically were mainly government-owned and over staffing may be present due to weak institutional frameworks as politicians often interfered in the affairs of the utilities (Lin 2005). The fourth input variable is *the length of the distribution voltage network* (DISNET - the physical level, measured in kilometres). We also used *quality of service* (QTYSER) as an [undesirable] input, measured as the number of outages in a year.

### 5.7.3 Output Variables

Three output variables are considered in this study. These are *energy delivered*, *the number of customers* (the aggregate number of people connected to the national grid) and *service area*. The energy delivered (ENERDED) records the amount of electricity generated minus the total transmission and distribution loss. A high distribution system loss is a factor to worry about as it could lead to frequent outages. In Africa and other developing economies utility regulators often-taxed the operators of the electricity distribution networks to ensure low distribution losses (World Bank, 2009).

We assumed the number of customers (CUSTOMER) has an exogenous influence on the distributors as there do not have power over who to supply power to or not. The service area (SERAREA) can be measured in different ways (Kittelsen, 1993). In this study, we use the number of the population that has access to electricity.

The service area (SERAREA) can be measured in different ways (Kittelsen, 1993). In this study, we use the number of the population that has access to electricity.

#### 5.7.4 Exogenous Factors

To account for variations in inefficiency beyond managerial ability we include exogenous variables. These factors can be either observable or unobservable (i.e. outside the distributor's control) and may affect efficiency. In this study, we prefer to refer or call it exogenous factor rather than environmental factors, because of the nature of the variables. As there are limited available data on environmental factors in the region. We used two exogenous factors; the first variable we consider is *Customer density* (CDENSITY - the number of customer per network kilometre).

Another exogenous variable we considered is The Peak load<sup>106</sup> (PLOAD) - the maximum load of the interconnected system(s) during a particular period in a year. In case a country has multiple interconnected systems, it is the sum of peak demands of each of the systems during a particular season in the year. In the case of Africa, consumer demand for electricity for the winter/rainy season may be double that for the summer/ dry season. The peak load does, largely, affect the technical efficiency of the distribution company.

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<sup>106</sup> **Peak load** refers to a period in which electricity distribution is expected to be significantly higher than average supply level. This is different from **peak demand**. In terms of energy use, peak demand is used to refer to a high point of consumer demand, which often attracts high billing. It is argued that peak users should bear the marginal operating and capital costs.



**Table 5.3: Data and Variables Description**

Index Name(s)	Unit	Variables used in the previous studies	Variable description
<b>Input Variables</b>			
Total operating expenditure (TOPEX)	US\$D (millions)	Giannakis et al.(2005);Hattori et al. (2005);Yu et al.(2009), Charnes et al.(1989); Miliotis (1982); Jamasb and Pollitt (2003); Korhonen and Syrjanen (2003); Giannakis, et al. (2005) Yang and Lu(2006); Growitsch et al.(2009);Coelli et al.(2013)	Comprises all recurrent costs plus depreciation plus financial costs (such as debt service and interest charges, foreign exchange losses), before taxes.
Length of the Distribution voltage networks (DISNET)	km	Giannakis et al.(2005); Mullarkey et al.(2015); Miliotis (1982); Zhang and Bartels (1998); Lo, Chien and Lin (2001), Chen (2002); Pacudan and de Guzman(2002) Resende(2002); Jamasb and Pollitt (2003); Korhonen and Syrjanen (2003); Estache et al.(2004);Giannakis, et al. (2005); Yang and Lu(2006); Coelli et al.(2013)	The total length of distribution networks in kilometres.
Number of Distribution transformers (NUMTRM)	Total number all rating (number)	Yang and Lu(2006);Resende(2002);Chen (2002);Lo, Chien and Lin (2001); Estache et al.(2004) used Transformer capacity; Pacudan and de Guzman(2002)	Total number of distribution transformers installed (all ratings).
Number of Employees (EMPLY)	(number)	Hattori (2002); Mullarkey et al.(2015); Pollitt(1995); Weyman-jones (1995); Zhang and Bartels (1998); Pacudan and de Guzman(2002); Estache et al.(2004);Resende(2002); Growitsch et al.(2009);	The number of full-time equivalent employees is calculated as the number of hours worked by full-time and part-time employees divided by the number of hours in a full working day.
Quality of service (QTYSER)	(number of occurrences per year)	Giannakis, et al. (2005); Coelli et al.(2013)	Frequency number of outage or blackouts in a number of days in a year.
<b>Output Variables</b>			
Energy delivered (ENERDED)	Gigawatt hour (GWh)	Giannakis et al.(2005); Hattori et al. (2005);Yu et al.(2009); Miliotis (1982); Bagdadioglu et al.(1996); Lo, Chien and Lin (2001); Pacudan and de Guzman(2002); Jamasb and Pollitt (2003); Giannakis, et al. (2005); Hattori et al.(2005); Yang and Lu(2006); Von Hirschhausen et al(2006)	Total electricity generation minus the total transmission and distribution loss.
Number of Customers (CUSTOMER)	(numbers)	Giannakis et al.(2005); Hattori et al. (2005); Mullarkey et al.(2015); Miliotis (1982); Pollitt(1995); Bagdadioglu et al.(1996); Zhang and Bartels (1998); Lo, Chien and Lin (2001); Chen (2002);Pacudan and de Guzman(2002); Resende(2002); Jamasb and Pollitt (2003); Korhonen and Syrjanen (2003); Giannakis, et al. (2005); Hattori et al. (2005); Yang and Lu(2006);Von Hirschhausen et al(2006); Estache et al.(2004); Growitsch et al.(2009);Coelli et al.(2013)	A total number of utility connections based on the total number of medium and low voltage users, High voltage users are not considered because these voltages are mainly for industrial users.
Service Area (SERAREA)	(%)	Mullarkey et al.(2015); Miliotis (1982); Pollitt(1995); Bagdadioglu et al.(1996); Pacudan and de Guzman(2002); Estache et al.(2004); Growitsch et al.(2009);Coelli et al.(2013)	Percentage of Population with access to electricity
<b>Exogenous Variables</b>			
Peak Load (PLOAD)	Annual-on-grid (MW)	Pacudan and de Guzman(2002); Giannakis, et al. (2005); Von Hirschhausen et al(2006)	The maximum load of the interconnected system(s) during the year in question. In the case where a country has multiple interconnected systems, it is the sum of peak demands of each of these systems.
Customer Density (CDENSITY)	Per km <sup>2</sup>	Hattori (2002); Hattori et al.(2005); Growitsch et al.(2009)	Number of people per square kilometre
<b>Reform Variables</b>			
Privatisation (PRZ)	Percentage	Zhang et al.(2008); Vagliasindi and Besant-Jones (2013)	Share capacity of private-owned capacities (%)
Regulation (REG)	Dummy	Zhang et al.(2008); Vagliasindi and Besant-Jones (2013)	0 =No independent or autonomous regulatory Agency. 1=Independent/autonomous regulatory Agency.
Competition(CMT)	Derived ratio (%)	Zhang et al.(2008); Vagliasindi and Besant-Jones (2013)	Percentage share of top 3 generating companies by capacity
Unbundling(UBN)	Dummy	Vagliasindi and Besant-Jones (2013)	0 = Vertical Integration 1= Restructuring through vertical separation
Load Factor (LOAD)	Ratio	Azad et al.(2015); Jamasb et al (2005)	Ratio of average energy delivered per hour to the maximum hourly demand
Fuel Type (FUEL)	Proportion (%)	Sarica and Or (2007); Diewert and Nakamura (1999); Pollitt (1995)	Share of oil/gas from the total net electricity generation

### 5.7.5. Data Structure and Countries Comparisons

An overview of the data is presented in table 5.4. The difference in size between utilities is large, as revealed by the high spread between the minimum and maximum values and the standard deviation. A summary of individual country data is shown in *table 5.5*. We simply take the geometric mean<sup>107</sup> or weighted average for each of the countries in the sample to evaluate their relative performance.

**Table 5.4:** Descriptive statistics of variables

Variable	Unit Measurement	Average	Standard Deviation	Minimum	Maximum
<b>Input Variables</b>					
Topex	US\$ dollars	62505525	170523924.6	6329.943	898439146
Disnet	Km	64059.34	119001.4	415	453502
Emply	numbers	8138.17	11422.11	659	47580
Numtrm	numbers	41036.85	108656.5	91	574420
Qtyser	number per year	2818.12	20040.37	4.2	223227
<b>Output Variables</b>					
Customer	numbers	2634031	5829500	20165	29700407
Enderded	Giga-watt hours (GWh)	23.71	53.535	0.129	223.57
Serarea	Percentage (%)	40.14	26.195	4.8	99.8
<b>Exogenous Variables</b>					
Cdensity	Per km <sup>2</sup>	73.52	48.304	2	191
Plaod	Annual-on-grid (MW)	4450.65	9638.071	38	44005
No of Observation	numbers	224			

With regard to table 5.5, the absolute size of the ‘big three’ (South Africa, Egypt, and Nigeria) is obvious in all dimensions, except for the quality of service (which is the number of outages for customers per year). South Africa tops the ranking in terms of total operating expenditure, the number of transformers installed, and the country with the largest number of electricity distribution companies, the largest distribution network length, management of peak load and the amount of energy delivered. It ranks second in percentage of the population with access to electricity (service area) and the number of customers. Egypt is largest with respect to the number of customers, and also the percentage of the populace with access to electricity. It was second in terms of the number of transformers, energy delivered, and

<sup>107</sup> The **geometric mean** is used commonly when comparing differences among countries, regions or firms (i.e. based on their merit or efficiency).

management of peak load. Nigeria registers the highest number of employees (EMPLY) and population density (CDENSITY). It ranked second in terms of distribution network length and number of electricity distribution companies. Namibia has the smallest number of distribution transformers (NUMTRM), customer numbers (CUSTOMER), population density (CDENSITY) and quality of service (QTYSER). The island of Cape Verde has the smallest distribution network length (DISNET), the lowest number of employees (EMPLY), energy delivered and the poorest peak load management. It ranks third in terms of the highest percentage of the service area (SERAREA) and the number of electricity distribution companies. Meanwhile, Uganda has the lowest operating cost in the study. Malawi has the lowest percentage of the population with access to electricity (SERAREA).

*Table 5.5: Geometric summary statistics, average country value (2000 – 2013)*

Country	TOPEX	DISNET	EMPLY	NUMTRM	QTYSER	CUSTOMER	ENERDED	SERAREA	PLOAD	CDENSITY
Cameroon	611923	19082	3378	6957	<b>1014</b>	537180	3.96	48	625.29	39.86
Cape Verde	<i>380390</i>	<i>714</i>	<i>705</i>	<i>252</i>	177	<i>67050</i>	<i>0.22</i>	<b>65</b>	<i>52.53</i>	118.50
Cote d'Ivoire	781998	17464	1519	8516	58	842885	4.39	56	610.57	56.37
Egypt	5078648	<b>120183</b>	<b>11142</b>	<b>136576</b>	57	<b>22892010</b>	<b>98.78</b>	<b>99</b>	<b>19407.98</b>	73.98
Ethiopia	4506863	21249	10768	9294	123	897811	3.01	19	558.05	79.09
Ghana	<b>278901321</b>	18573	4394	8778	286	245793	6.24	56	1364.77	82.56
Kenya	9949767	22042	5758	4035	78	875772	4.98	22	959.09	65.47
Malawi	535550	<b>3646</b>	2133	1066	141	<b>165859</b>	<i>1.5</i>	<b>8</b>	<b>271.41</b>	<b>143.81</b>
Mozambique	3967623	8797	3117	<i>154</i>	<b>22</b>	326292	11.85	<i>10.3</i>	<b>360.79</b>	<i>27.70</i>
Namibia	2688694	19123	<b>902</b>	<i>145</i>	<b>6.3</b>	<b>43953</b>	<i>1.32</i>	40.4	514.56	<i>2.45</i>
Nigeria	366924	<b>198284</b>	<b>39861</b>	<b>21766</b>	<b>303</b>	<b>3902861</b>	<b>16.43</b>	48	<b>4282.12</b>	<b>159.79</b>
Senegal	608249	11847	2418	3493	<b>938</b>	573212	1.66	49.2	407.38	61.06
South Africa	<b>596212260</b>	<b>399359</b>	<b>32771</b>	<b>427930</b>	<i>16</i>	<b>8575700</b>	<b>205.97</b>	<b>75.32</b>	<b>35668.28</b>	39.94
Tanzania	<i>228556</i>	22421	5065	7168	149	625358	2.82	<i>12.24</i>	1894.8	43.89
Uganda	<i>56282</i>	<i>8789</i>	<i>1425</i>	5419	241	294724	1.91	12.6	435.4	<b>151.18</b>
Zambia	<b>31108279</b>	17801	3855	1036	45	326777	8.2	18.6	1490.6	<i>16.18</i>

\*\*\* The top three are in **bold**, while the three lowest are in *italics*

## 5.8. Methodology

In this study, we expand upon the SFA production function as used by Coelli *et al.* (2013) and Growitsch *et al.* (2009) based on the panel data method. We estimated four models<sup>108</sup>, with each model consisting of two steps. This is to enable us to verify the impact of exogenous factors on the level of technical efficiency of each of the country EDISCOs. Therefore, we incorporated the number of interruptions (a proxy for quality of service) as an undesirable input as one of the four input variables (see Coelli *et al.* 2013, Growitsch *et al.* 2009 and Giannakis *et al.* 2005). Our assumption is that a rational electricity distribution operator considers the penalty (imposed by the regulator) for a frequent interruption of power supply and compares it with the price of the input variables needed to prevent interruptions, and then decides on the best production options.

Table 5.6 summarises the various models employed in the analysis.

**Table 5.6:** Model specification and variables employed for analysis

	Model 1	Model 2	Model 3	Model 4
<b>Inputs</b>				
Reference Variable: Total operating cost	✓	✓	✓	✓
$X_1$ : Number of Transformers installed	✓	✓	✓	✓
$X_2$ : Number of Employees	✓	✓	✓	✓
$X_3$ : Length of Distribution Network	✓	✓	✓	✓
$X_4$ : Quality of Service (undesirable input)			✓	✓
<b>Output</b>				
$Y_1$ : Energy Delivered	✓	✓	✓	✓
$Y_2$ : Number of Consumers	✓	✓	✓	✓
$Y_3$ : Service Area	✓	✓	✓	✓
<b>Exogenous</b>				
$Z_1$ : Customer Density		✓		✓
$Z_2$ : Peak Load		✓		✓

<sup>108</sup> The logic of estimating four models is to enable us to examine the direct impact of exogenous factors on the technical efficiency of electricity distribution companies and to examine the impact of quality of service (i.e. the number of outages) on the efficiency level of the EDISCOs in the region.

### **5.8.1 Model 1 (General)**

This is the general model and all other models treated in this study employ a variation of the variables used in this model. It incorporates the key variables (*inputs and outputs*) used in the industry that impact on the technical efficiency level of the electricity distribution companies. We estimated the Input Distance Function alone.

### **5.8.2 Model 2 (Traditional)**

Exogenous factors affecting the technical efficiency of electricity distribution companies were found by previous scholars such as Mullarkey *et al.* (2015); Coelli *et al.* (2013); Yu *et al.* (2009); and Growitsch *et al.* (2009) to have important efficiency effects. In this study, we use *peak load* and *customer density* as our exogenous factors.

### **5.8.3 Model 3 (Quality of Service)**

Model 3 incorporates the quality of service variable (which is the number of interruptions in a year) as an undesirable input variable. That is, we treat the number of outages as a ‘bad’ input based on an assumption that there is a substitutive relationship between total operating cost and number of outages. This interruption in customer service could be in the form of both unplanned interruptions and planned ones (due to routine maintenance of the network).

### **5.8.4 Model 4 (Comprehensive)**

Due to the weaker institutional nature of the electricity distribution industry in developing countries, we extended model 3 to include exogenous factors which can affect the quality of service.

## **5.9. Tests of Hypotheses**

It has been argued that inclusion of quality of service into technical efficiency analysis tends to alter the optimal firm size. Kwoka (2005) suggested that the smaller the firm size, the better in terms of reliable quality of service. This is because they are closer to the end users and have better customer information (i.e., they have a higher degree of responsiveness, for instance, how long does it take the operators to restore power when there is outage or connect customer to the grid)?

Moreover, any country that has a small number of electricity distribution companies tends to have higher economies of scale (as these firms enjoy a relatively lower cost over the country with many utility firms).

In this study, we seek to verify the following hypotheses;

- (i) Exogenous factors (such as customer density and peak load) do have a significant impact on the technical efficiency of EDISCOs in the region.
- (ii) As regulators set the benchmark for the quality of service, EDISCOs respond by either improving their service to achieve the target, or face the penalty. Thus in order to avoid the penalty, they improve their performance (i.e., technical efficiency).
- (iii) Whether countries that adopted market-oriented reforms in their electricity distribution sector performed better than others that did not.
- (iv). That a country with many and/or large EDISCOs is more efficient than countries with less/few EDISCOs (*economies of scale*).

In our model estimation, we compared the sixteen countries' performances against each other to identify if a particular country or a group of specific countries dominate. We then conducted consistency or robust checks by excluding a particular country and checking if there was a significant difference in the industry technical efficiency. The estimated technical efficiency levels will be used to rank EDISCOs, to identify under-performing EDISCOs, and those at, or close to, the efficiency frontier. This information is, in turn, useful in helping governments in the region to design public policies or programmes to improve the overall efficiency level of both private and public companies in the industry (Kumbhakar *et al.* 2015).

### **5.9.1 Correlation Analysis of Input and Output Variables**

We analysed the relationship between input and output variables using correlation techniques. In principle, input and output variables are expected to be positively correlated (Mullarkey *et al.* 2015). Therefore, the higher the degree of correlation between the input and output variable, the stronger the tendency of the relationship will be. Table 5.7 shows the correlation coefficients for the respective inputs/outputs. The correlation between the input and output variables is in the range of 0.2 to 0.9.

From Table 5.7, it can be concluded, as we might expect, that there exists a strong relationship between the *number of transformers (installed)* and the *Energy delivered* (Pearson's value of 0.9729). It implies that as the number of power transformers installed increases, it leads to an increase in the energy supply to the consumers, thereby reducing the transmission and distribution losses. Likewise, the table shows there is a weak relationship between *Total operational cost* and *number of customers* (0.2039).

**Table 5.7: Correlation outcome between Input and Output variables**

	X1:Topex	X2:Numtrm	X3:Emply	X4:Disnet	Y1:Enerded	Y2:Customer	Y3:Serarea
X1:TOPEX	1.0000						
X2:Numtrm	0.8301	1.0000					
X3:Emply	0.4843	0.6180	1.0000				
X4:Disnet	0.6113	0.8383	0.7880	1.0000			
Y1:Enerded	0.7531	<b>0.9729</b>	0.6042	0.8836	1.0000		
Y2:Customer	<b>0.2039</b>	0.5478	0.3934	0.6762	0.6791	1.0000	
Y3:Serarea	0.3939	0.5269	0.3360	0.5500	0.5795	0.6836	1.0000

The assumption of *isotonicity* between the input and output variables is satisfied. Literally, it means that the relationship between input and output should not be erratic. Thus, increasing the value of the input variable does not lead to a decrease in the output, but rather to an increase in the value of output.

## 5.10. Estimation, Results, and Discussion

The estimated coefficients of the four models are presented in *table 5.8* (the maximum likelihood approach was employed in the estimation). All the variables are expressed in logarithmic deviations from mean values. The first order coefficients that are associated with outputs and the inputs may be interpreted as distance function elasticities. Some gamma ( $\gamma$ ) variables were removed because of collinearity problems.

The *first* column in *table 5.8* contains an indication of the parameters of all the models which are the translog specification for the production function. The *second* column identifies the variables employed in each of the models. The *final four columns* represent our modelling results (Models 1 – 4).



Model 1 could be referred to as the *General Model*. In this model, only the *log of customers* was significant of the first order and with a correct sign, while *energy delivered squared* and the *number of customers squared* are statistically significant at the second order.

Model 2 accounts for the impact of exogenous factors on the EDISCOs performance. Our result shows that only *log of customers* is statistically significant in the first order, though both output and input variables show the expected signs. However, in the second order, the *log of customers squared* is the only statistically significant variable.

Model 3 incorporated the quality of service as an undesirable input in the model. Our results show *log of energy delivered, log of customers and log of employees* are statistically significant at the first order coefficient. In the cross-term effects (*i.e. the second order*), it is the only *log of customers squared* that is statistically significant.

In model 4, we added exogenous factors to the model 3 specifications. Our result shows that the output variable *log of energy delivered* and an input variable (*log of employees*) are significant of the first order. Also at the second order *log of energy delivered* is statistically significant.

### **5.10.1 Efficiency Estimates**

The parameter estimates are interpreted based on stochastic frontier analysis. All the variables in Table 5.8 contain information on distance function elasticities for models (1 - 4) concerning the input variables used in producing the output variables. Equation 5.9 and 5.10 are the elasticities of distance function of the input and the output shares.

The coefficient of input variables used show that only the estimated elasticity of *number of employees* is significant, and the only significant estimated elasticities of the output variables on *the number of customers* and *energy delivered*. Therefore as the elasticity of the mean value of the output values is increasing, if the number of customers connected to the national grid increases by 1%, the demand of energy supply is raised by 1%. Thus there is no corresponding increase in input variables (*distribution line length of the network, the number of employees and the number of transformers installed* to meet the demand of customers). As shown in the results, all the input variables have negative signs (*except for distribution line length in model 3*), indicating a decrease in the value of the efficiency estimates of the electricity distribution companies. As the technical efficiency in table 5.8 ranges between 0.89 and 0.90, with an average efficiency of 0.895, this implies a technical inefficiency level of 12.4% for the electricity distribution companies in the region.

However, it is possible for countries with high output-input utilisation ratios in electricity distribution (in terms of the number of customers per employee ratio) to perform less well in terms of technical efficiency scores when compared to countries with a low number of customers per employee ratio. Moreover, our findings show an increase in technical efficiency of 1% in model (3) and (4) when *the quality of service variable* is incorporated into the model, which implies that the management of the electricity distribution companies are mindful when there is a regulatory body in a country, (whose duty is to effectively monitor and set benchmarks on the quality of services).

**Table 5.8: Estimated results of parameters of the Input distance production function on Technical Efficiency**

Parameters	Variables	Model 1	Model 2	Model 3	Model 4
		IDF Alone	IDF with EXF	IDF with QS	IDF with QS &EXF
$\alpha_0$	constant	-153.459*** (16.294)	-154.806***(17.1358)	-148.9253*** (17.6599)	-244.8423*** (24.9438)
$\alpha_1(\ln y_1)$	lnenedred	-0.0264 (0.1024)	-0.0212 (0.1021)	-0.2094* (0.1114)	-0.5322*** (0.1542)
$\alpha_2(\ln y_2)$	lncustm	0.1959** (0.0694)	0.2023*** (0.0684)	0.1287* (0.0754)	0.0124 (0.0899)
$\alpha_3(\ln y_3)$	lnserarea	-0.0275 (0.0929)	-	-	-
$0.5\alpha_{11}(y_1^2)$	lnenedred <sup>2</sup>	-1.1883* (0.7132)	-1.1048 (0.7336)	0.2297 (0.6447)	2.4072** (1.2191)
$0.5\alpha_{22}(y_2^2)$	lncustm <sup>2</sup>	-0.0026** (0.0008)	-0.0027*** (0.0008)	-0.0016* (0.0009)	-0.0051 (0.0011)
$0.5\alpha_{33}(y_3^2)$	lnserarea <sup>2</sup>	0.0011 (0.0093)	0.0023 (0.0094)	0.0007 (0.0093)	0.0039 (0.0108)
$\alpha_{12}(y_1 * y_2)$	lncustded	-0.0325 (0.1359)	-0.0280 (0.1333)	-0.0294 (0.0217)	-0.0786*** (0.0246)
$\alpha_{13}(y_1 * y_3)$	lnenearea	-0.0227 (0.1103)	-0.0293 (0.1099)	-0.02639 (0.9996)	-0.0665 (0.1208)
$\alpha_{14}(y_2 * y_3)$	lncustarea	-0.1444 (0.1061)	-0.1488 (0.1049)	-0.1533* (0.0862)	-0.0789 (0.0920)
$\beta_1(\ln x_{2n})$	lnnumtrm	-0.0978 (0.1137)	-0.1077 (0.1132)	-0.0319 (0.0967)	-0.1231 (0.1314)
$\beta_2(\ln x_{3n})$	lnempty	-0.8881*** (0.1836)	-0.8899*** (0.1849)	-0.6788*** (0.2001)	-1.2500*** (0.2328)
$\beta_3(\ln x_{4n})$	lnindisnet	-0.0889 (0.0889)	-0.0941 (0.0909)	0.1143 (0.0794)	-0.1247 (0.0825)
$0.5\beta_{11}(x_2^2)$	lnnumtrm <sup>2</sup>	0.1109* (0.0603)	0.1187* (0.0616)	0.0089 (0.0318)	0.0296 (0.0399)
$0.5\beta_{22}(x_3^2)$	lnempty <sup>2</sup>	8.4122 (6.0001)	8.2942 (6.0188)	1.2992 (6.1673)	2.5464 (6.6769)
$0.5\beta_{33}(x_4^2)$	lnindisnet <sup>2</sup>	0.5088*** (0.1738)	0.5296 *** (0.1805)	0.0556 (0.1346)	0.1847 (0.1362)
$\beta_{12}(x_2 * x_3)$	lnnumply	-2.0989*** (0.7764)	-2.1883*** (0.7935)	-----	-----
$\beta_{13}(x_2 * x_4)$	lnnumnet	0.4267 (0.2899)	0.4601 (0.2932)	-----	-----
$\beta_{14}(x_2 * x_4)$	lnempnet	2.5076*** (0.6435)	2.5797*** (0.6591)	-----	-----
$\gamma_1(y_1 * x_2)$	lnenedply	-0.7982 (0.6235)	-7.0752 (0.6243)	-----	-----
$\gamma_2(y_1 * x_3)$	lnenedtrm	0.3739 (0.2988)	0.3795 (0.2962)	-----	-----
$\gamma_3(y_1 * x_4)$	lnenednet	0.0013 (0.2859)	-0.0583 (0.3051)	-----	-----
$\gamma_4(y_2 * x_2)$	lncustply	-0.1454 (0.1117)	-0.1462 (0.1108)	-----	-----
$\gamma_5(y_2 * x_3)$	lncusttrm	0.1568 (0.2502)	0.1472 (0.2463)	-----	-----
$\gamma_6(y_2 * x_4)$	lncustnet	-0.0209*** (0.0061)	-0.0216*** (0.0061)	-----	-----
$\gamma_7(y_3 * x_2)$	lnserply	0.1392 (0.1617)	0.1341 (0.1612)	-----	-----
$\gamma_8(y_3 * x_3)$	lnsertrm	-0.0474 (0.0439)	-0.0485 (0.4388)	-----	-----
$\gamma_9(y_3 * x_4)$	lnsernet	-0.0268 (0.0974)	-0.0202 (0.0981)	-----	-----
$\gamma_{10}(\frac{x_4}{y_5})$	lnsaifi	-----	-----	0.0018 (0.0015)	-0.0016 (0.0025)
$\gamma_{11}(\frac{x_4}{y_5})^2$	lnsaifi <sup>2</sup>	-----	-----	-0.0004 (0.0004)	0.0004 (0.0006)
$\gamma_{12}(\frac{x_4}{y_5}) * y_1$	lnsaifded	-----	-----	-0.0193* (0.0093)	-0.0341** (0.0156)
$\gamma_{13}(\frac{x_4}{y_5}) * y_2$	lnsaifcust	-----	-----	-0.0008 (0.0006)	-0.0009 (0.0010)
$\gamma_{14}(\frac{x_4}{y_5}) * y_3$	lnsaifarea	-----	-----	-0.0006 (0.0018)	0.0003 (0.0019)
$\gamma_{15}(\frac{x_4}{y_5}) * x_2$	lnsaiftrm	-----	-----	0.0148* (0.0069)	0.0137 (0.0104)
$\gamma_{16}(\frac{x_4}{y_5}) * x_3$	lnsaifply	-----	-----	0.0090 (0.0123)	-0.0047 (0.0172)
$\gamma_{17}(\frac{x_4}{y_5}) * x_4$	lnsaifnet	-----	-----	0.0029 (0.0019)	0.0025 (0.0022)
Z-variables	Exogenous Factors				
$z_1(\varphi_1)$	Peak Load	-----	-0.0165 (0.0231)	-----	-0.0594*** (0.0193)
$z_2(\varphi_2)$	Customer Density	-----	0.0356 (0.0468)	-----	0.0310 (0.0501)
Time (years)	t <sup>2</sup>	0.0765*** (0.0081)	0.0772*** (0.0085)	0.0743*** (0.0088)	0.1222*** (0.0124)
	Log likelihood	115.366	115.987	98.792	60.895
bc_t	Tech_Efficiency	0.89	0.89	0.89	0.79
	Number of Obs	224	224	224	224

Note: Significance; \*\*\*:1% level, \*\*: 5% level, \*: 10% level. Standard errors are reported in Parentheses

**IDF** represents Input Distance Function

**EXF** denote Exogenous Factors

**QS** stands for Quality of Service

### 5.10.2 Robustness Check

Our motivation in this section is to identify if excluding the Republic of South Africa (the dominant producer in the region) from the estimation has a significant impact on the technical efficiency level of the electricity distribution companies in the region.

Table 5.9 shows the technical efficiency of EDISCOs (without the Republic of South Africa) in the model. Most of the estimated parameters are statistically significant at the 1% and 10%, which corresponds to a good fit of the models estimated. Most of the first-order coefficients have correct signs; which implies that the monotony conditions required by economic theory are satisfied, and that the input distance function is monotonically increasing in inputs and decreasing in outputs.

In Model 7, Saifi<sup>109</sup> was incorporated into the model and the following variables are statistically significant; the output variable of the *log of energy delivered* and the input variable of the *log of employees*. The estimated parameter of the *time trend* in table 5.9 suggests the mean inefficiency is statistically significant and positive, which implies a decrease in efficiency level of the distribution companies. However, other parameters estimated offer more insights into the technical efficiency levels – the *energy delivered* and *energy delivered square* with their corresponding signs in both model (7) and (8) respectively. These results reveal that without South Africa there is a significant decrease in energy supplied by these EDISCOs in the region, especially in model 8. Similarly, when comparing the efficiency level of distribution companies without South Africa, the average technical efficiency decreased by 3% from 90% to 87%.

However, the impact of exogenous factors on the performance of electricity distribution companies is weak, except in model 8, where peak load is positive and statistically significant. This reveals that the electricity distribution companies find it difficult to meet power demand during the peak periods, which impacts on their efficiency level.

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<sup>109</sup> SAIFI is derived by taking the total number of customer interruptions divided by the total operating cost.

Table 5.9: Estimated result of parameters of the Input distance production function without South Africa

Parameters	Variables	Model 5		Model 6		Model 7		Model 8	
		IDF Alone		IDF with EXF		IDF with QS		IDF with QS & EXF	
$\alpha_0$	constant	0.6000***	(17.576)	0.6000***	(18.4225)	0.4999***	(18.7424)	0.4999***	(28.4815)
$\alpha_1(y_1)$	lnenerd	0.991	(0.1989)	0.9917	(0.2340)	0.9961***	(0.2336)	0.9005***	(0.3242)
$\alpha_2(y_2)$	lncustm	-0.0009***	(0.1724)	0.0005	(0.1832)	0.0068	(0.1407)	-0.0133	(0.1392)
$\alpha_3(y_3)$	lnserarea	-0.0363	(0.2489)	-0.0433	(0.2555)	0.0006	(0.1793)	-0.0003	(0.1827)
$0.5\alpha_{11}(y_1^2)$	lnenerd <sup>2</sup>	-0.9012*	(1.1995)	-1.3011	(1.2868)	-0.6005	(1.1949)	-0.7999	(1.3679)
$0.5\alpha_{22}(y_2^2)$	lncustm <sup>2</sup>	-0.0001	(0.0021)	-0.0007	(0.0022)	-0.0001	(0.0017)	-0.0002	(0.0017)
$0.5\alpha_{33}(y_3^2)$	lnserarea <sup>2</sup>	0.0004	(0.0241)	0.0006	(0.0248)	-0.0009	(0.0176)	0.0001	(0.0179)
$\alpha_{12}(y_1 * y_2)$	lncustd	0.0074	(0.2921)	0.0077	(0.2974)	-0.0904	(0.0454)	-0.0086	(0.0491)
$\alpha_{13}(y_1 * y_3)$	lnenearea	0.0019	(0.2331)	0.0023	(0.2347)	-0.0015	(0.1985)	-0.1938	(0.1264)
$\alpha_{14}(y_2 * y_3)$	lncustarea	-0.1443	(0.1112)	-0.1978	(0.1354)	-0.1985*	(0.1334)	-0.1938	(0.1264)
$\beta_1(x_1)$	lnnumtrm	0.6997***	(0.2362)	0.6996***	(0.2576)	0.6017***	(0.1762)	0.5067**	(0.2662)
$\beta_2(x_2)$	lnemply	-0.9016***	(0.4739)	-0.9014	(0.4755)	-0.6008	(0.4619)	-0.5991	(0.5006)
$\beta_3(x_3)$	lnindisnet	0.1947	(0.0934)	0.1952	(0.2278)	0.2025	(0.1511)	0.1044	(0.1739)
$0.5\beta_{11}(x_1^2)$	lnnumtrm <sup>2</sup>	-0.0876*	(0.1682)	-0.0862	(0.1775)	-0.1968***	(0.0585)	-0.1886**	(0.0845)
$0.5\beta_{22}(x_2^2)$	lnemply <sup>2</sup>	-2.0001	(14.3063)	-20001.	(14.429)	-2.0004	(17.0948)	-2.0000	(15.5542)
$0.5\beta_{33}(x_3^2)$	lnindisnet <sup>2</sup>	-0.0019	(0.3868)	-0.0015	(0.4652)	0.0011	(0.2437)	-0.0007*	(0.3162)
$\beta_{12}(x_1 * x_2)$	lnnumply	-0.7979	(2.0085)	-0.7978	(2.0342)	-----	-----	-----	-----
$\beta_{13}(x_1 * x_3)$	lnnumnet	-0.4949	(0.7097)	-0.4949	(0.7152)	-----	-----	-----	-----
$\beta_{14}(x_2 * x_3)$	lnempnet	-1.3981	(1.0523)	-1.2981	(1.0687)	-----	-----	-----	-----
$\gamma_1(y_1 * x_2)$	lnenedply	0.6014	(1.8252)	-0.6014	(1.8437)	-----	-----	-----	-----
$\gamma_2(y_1 * x_1)$	lnenedtrm	0.6955	(0.5126)	-0.7951	(0.7164)	-----	-----	-----	-----
$\gamma_3(y_1 * x_3)$	lnenednet	0.1053	(0.6621)	0.1052	(0.7164)	-----	-----	-----	-----
$\gamma_4(y_2 * x_2)$	lncustply	0.0031	(0.3122)	0.0031	(0.3175)	-----	-----	-----	-----
$\gamma_5(y_2 * x_1)$	lncusttrm	-0.1941	(0.5285)	-0.1937	(0.5479)	-----	-----	-----	-----
$\gamma_6(y_2 * x_3)$	lncustnet	-0.0612	(0.0188)	0.056	(0.0199)	-----	-----	-----	-----
$\gamma_7(y_3 * x_2)$	lnserply	0.1004	(0.3831)	0.1005	(0.3911)	-----	-----	-----	-----
$\gamma x_1$	lnsertm	0.0057	(0.1195)	0.0067	(0.1263)	-----	-----	-----	-----
$\gamma_9(y_3 * x_3)$	lnsernet	0.0018	(0.2282)	0.0019	(0.2393)	-----	-----	-----	-----
$\gamma_{10}(\frac{x_4}{y_5})$	lnsaifi	-----	-----	-----	-----	0.0046	(0.0036)	0.0028	(0.0041)
$\gamma_{11}0.5(\frac{x_4}{y_5})^2$	lnsaifi <sup>2</sup>	-----	-----	-----	-----	-0.0001	(0.0009)	-0.0002	(0.0005)
$\gamma_{12}(\frac{x_4}{y_5}) * y_1$	lnsaifded	-----	-----	-----	-----	-0.0070*	(0.0211)	-0.0013	(0.0233)
$\gamma_{13}(\frac{x_4}{y_5}) * y_2$	lnsaifcust	-----	-----	-----	-----	-0.0014	(0.0018)	-0.0004	(0.0017)
$\gamma_{14}(\frac{x_4}{y_5}) * y_3$	lnsaifarea	-----	-----	-----	-----	-0.0027***	(0.0033)	-0.0021	(0.0037)
$\gamma_{15}(\frac{x_4}{y_5}) * x_1$	lnsaiftrm	-----	-----	-----	-----	0.0035*	(0.0149)	0.0008	(0.0154)
$\gamma_{16}(\frac{x_4}{y_5}) * x_2$	lnsaifply	-----	-----	-----	-----	0.0107	(0.0279)	-0.0043	(0.0286)
$\gamma_{17}(\frac{x_4}{y_5}) * x_3$	lnsaifnet	-----	-----	-----	-----	0.0049	(0.0037)	0.0030*	(0.0035)
	Exogenous Factors								
$\theta_1(\varphi_1)$	Peak load	-----	-----	-0.1061	(0.0531)	-----	-----	-0.0045	(0.0413)
$\theta_2(\varphi_2)$	Customer Density	-----	-----	0.1955***	(0.0807)	-----	-----	0.3927	(0.0750)
Time (years)	t <sup>2</sup>	0.07476***	(0.0088)	0.0006**	(0.0003)	0.0006***	(0.0009)	0.0007***	(0.0001)
	Log likelihood	-46.700077		-46.63441		-25.405337		-31.882418	
	Technical Efficiency	0.72		0.72		0.747		0.743	
	Number of Obs	200		200		200		200	

Note: Significance; \*\*\*:1% level, \*\*: 5% level, \*: 10% level. Standard errors are reported in Parentheses

### 5.10.3 Model Selection

In this section, we employed log-likelihood ratio (LR) test to choose the preferred model. We start with the general model, the log-likelihood-ratio test for the stochastic frontier for model 1 as against model 2, and for model 3, as against model 4. The null hypothesis state that adding exogenous variables does not improve the model. However, the alternate hypothesis stated that including the exogenous variables do have a significant impact in the model.

The LR test for the model 1 against 2, we reject the null hypothesis and state that electricity exogenous variables affects the efficiency of distribution companies (i.e. there do consider the peak load and service area in their production function). In the second test, we compare the model 3 and model 4 (i.e. when the undesirable variable - *the quality of service enter the DISCOs production function, also exogenous variables considered in the model*). As the DISCOs works to meet the targets set by the regulators, the log-likelihood test shows that we fail to reject the null hypothesis, but indicated that in the presence of quality of service alone in the production function is preferred to the combination of exogenous factors and the quality of services. However, we should not read too much meaning to the likelihood ratio test.

In table 5.9, the log-likelihood ratio results were all in negative signs. This could be as result of excluding South Africa from the model (i.e. South Africa constitute an outlier in the model). The LR test in table 5.9 corresponds to previous test in table 5.8, (i.e. we preferred Model 6 to model 5 and model 7 to that of 8).

#### 5.10.4 Second Stage Estimation

In this section we adopted a two-step approach (*see chapter four model specification*). After calculating the technical efficiency score of the EDISCOs in the region, we assess the impact market-oriented reform has on the electricity distribution companies' performance (i.e., the technical efficiency). The panel data approach enables us to investigate whether a company effect is fixed or is random. Likewise, we compared the effect of the reform on each country, recognising the heterogeneity effect in the model. We conducted the Hausman specification test to select the preferred model (i.e. either a fixed effect model or random effect model).

Thus, we signify the equation.

$$Teff_{it} = f(Prvz_{it}, Regu_{it}, Cmpt_{it}, Unbn_{it}, Nedcs_{it}, Load_{it}, Fuel_{it},) \quad (5.13)$$

Where,  $i$  is the country,  $t$  is the years of observation.  $Teff$  is the technical efficiency, **Prvz** denotes Privatisation of the EDISCOs, **Regu** represents Independent regulator, **Cmpt** stands for competition in the industry, and **Unbn** represents Unbundling. Similarly, we included control variables in the model, such as *Load factor* and *Fuel type*, these being the *key determinants* of the company's technical efficiency. **Nedcs** represents the number of electricity distribution companies in each country.

Regulation, and Unbundling are market reform dummies variable assigned 1 for the years following adoption of reform, and zero (0) for years without reform in each of the countries. Privatisation represented the percentage share of private-owned capacities, and Competition is a concentration ratio measured as the total electricity output of the three highest EDISCOs in the sector.

In equation 5.14, we included individual country, time specific dummies, and reform variable interaction effects in the model. We formulate a Fixed or Random effect model (*equation 5.14*), to analyse the combined impact of market-oriented policies on the electricity distribution companies' technical efficiency in Africa.

$$Teff_{it} = \varphi_i + \beta_1(Prvz_{it}) + \beta_2(Regu_{it}) + \beta_3(Cmpt_{it}) + \beta_4(Unbn_{it}) + \delta(X)_{it} + v_i + u_t + \varepsilon_i \quad (5.14)$$

Where  $X_{it}$  denotes the control variables (Load Factor, Fuel Type and Number of electricity distribution companies).  $v_i$ , represents the unit-specific residual that differs between countries, (but remains constant for any particular country), while  $u_t$  denotes the time effect (which differs across years but is constant for all countries in a particular year) and  $\varepsilon_i$  stands for the error term. Based on our prior expectations, we estimate model (5.14) to explore the two, three and four variable interaction effects. Also we identify the coefficient of the shock ( $v$ ) in the estimation model as ( $v$ sigmas), and that of  $u$  with  $u$ sigmas.

Figure 5.5<sup>110</sup> illustrates the overall trend of technical efficiency of the countries over the period observed. As revealed in the figure, the Cameroon and Uganda electricity distribution companies' technical efficiency started at a lower level than other countries, but have shown a gradual improvement. Meanwhile, South Africa and Egypt started with high levels of efficiency but have experienced deteriorations in the quality of electricity supply over the period. This is attributable to inadequate planning and maintenance from Eskom (South Africa national utility company) and the municipal councils respectively. The political uprising in Egypt also negatively impacted on the quality and efficiency of the distribution companies in the country between 2011 and 2012 (KPMG, 2015).

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<sup>110</sup> Where TEFF denotes Technical Efficiency, t is the years (2000-2013), Idcode 1-16 indicates countries. Idcode1-Cameroon, idcode2-Cape Verde, idcode3-Cote d'Ivoire, idcode4-Egypt, idcode5-Ethiopia, idcode6-Ghana, idcode7-Kenya, idcode8-Malawi, idcode9-Mozambique, idcode10-Namibia, idcode11-Nigeria, idcode12-Senegal, idcode13-South Africa, idcode14- Tanzania, Idcode 15- Uganda, and Idcode16-Zambia.

### 5.11 The Impact of Market-Oriented reform Policies on the EDISCOs Performance

Table 5.10 shows that the fixed effect model is preferred over the random effect and pooled regression model based on the Hausman specification test. To establish to what extent market-oriented policies influence the electricity distribution companies' performance (i.e. *technical efficiency*) we will concentrate our interpretation on model 4, while models (1), (3) and (5) will be used for comparative purposes. In model 4 only unbundling among the reform variables is statistically significant and positively associated with electricity distribution companies' performance. However, our control variables (such as *the type of fuel used*, and *capacity load*) are statistically significant, but are negatively associated with technical efficiency, which contradicts economic theory, which reveals that gas fired power plants are more efficient than power plants based on other sources of energy. The overload of installed transformers in the region leads to the negative sign on the variable.

Individually (except for unbundling) the other reform indicators used are not sufficient to increase the technical efficiency level of the electricity distribution companies in the region. Moreover, the interaction effect variables *regulation* and *unbundling* are statistically significant, but negatively associated with an increase in EDISCOs technical efficiency.

In other words, regulatory effects undermine the effect of separation of the entities. Similarly, when *competition* co-exists with *unbundling*, this is statistically significant at 5%, but negatively associated with the electricity distribution companies' technical efficiency. It implies that unbundling is less effective in a country with little or no competition in the sector. Most African countries only introduced limited competition, as the state-owned utility companies dominate the industry.

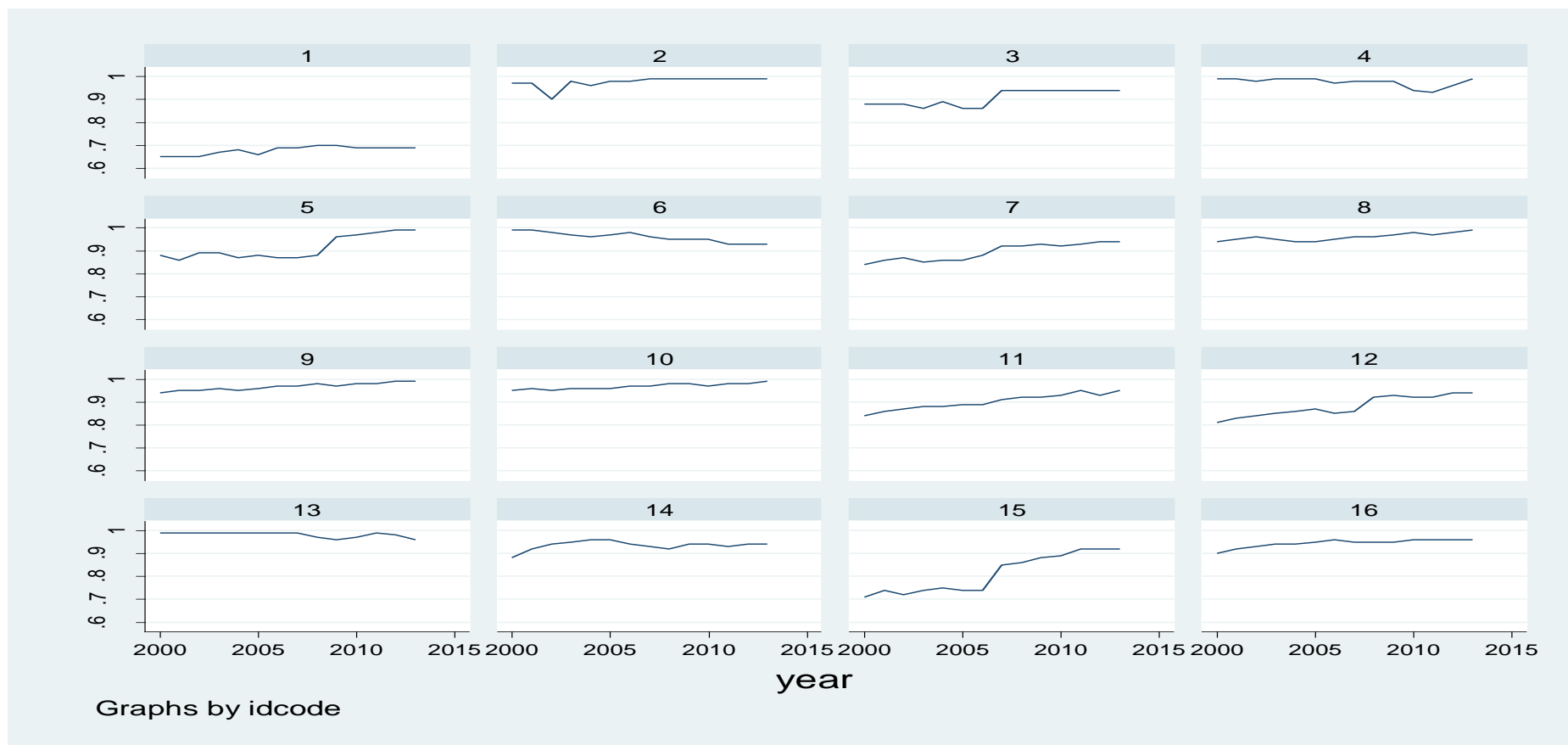
However, when considering the three by three interaction effect, our result reveals that the co-existence of *regulation*, *competition* and *unbundling* were statistically significant and positively associated with an increase in the electricity distribution companies efficiency level. Thus, African countries have to deepen their restructuring, as our finding suggests, in order to obtain optimal results, each country should adopt at least three reforms. This result is consistency with Zhang et al. (2008), although differs in that Zhang et al. (2008) did not estimate a three by three interaction effect model.

Lastly, with the time effect in all the models, year 2007 is the turning point among the countries examined. All coefficients for the year (2007) are statistically significant and positively



associated with an increase in technical efficiency in the region, with the average of distribution losses across the region at their lowest (average of 16.99%).

Figure 5.5: Technical Efficiency of Electricity Distribution Companies over time in the Region



Source: Authors construct (STATA 13)

Table 5.10: Second stage Estimation Results

Explanatory Variables	Pooled Regression Result		Fixed Effect Result		Random Effect Result	
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
PRVZ	0.0001 (0.0001)	0.0004 (0.0009)	-0.0001 (0.0005)	0.0003 (0.0004)	-0.0926 (0.0001)	0.0004 (0.0009)
REGU	-0.0364** (0.0168)	-0.1654 (0.1044)	-0.0019 (0.0078)	-0.0048 (0.0431)	-0.0025 (0.0077)	-0.1654 (0.1045)
CMPT	-0.0005** (0.0002)	-0.0011 (0.0039)	0.0002 (0.0002)	0.0001 (0.0006)	0.0002 (0.0002)	-0.0011 (0.0014)
UNBN	-0.0350** (0.0135)	0.0262 (0.1059)	0.0110 (0.0075)	0.1085** (0.0438)	0.0107 (0.0075)	0.0262 (0.1059)
FUEL	0.0103** (0.0058)	0.2040*** (0.0627)	-0.0148*** (0.0380)	-0.0142*** (0.0440)	-0.0142*** (0.0373)	0.0204*** (0.0627)
LOAD	-0.0002 (0.0005)	-0.0004 (0.0005)	-0.0002 (0.0004)	-0.0003 (0.0005)	-0.0002 (0.0004)	-0.0004 (0.0005)
NEDCs	-0.0009 (0.0008)	-0.0022*** (0.0008)	omitted	omitted	0.0022 (0.0007)	-0.0022 (0.0008)
<b>Interaction Effects</b>						
PRZCMP	-----	0.2340 (0.00001)	-----	-0.0471 (0.0514)	-----	0.0234 (0.00001)
PRZREG	-----	-0.0002 (0.0020)	-----	-0.0001 (0.0005)	-----	-0.0002 (0.0012)
PRZUBN	-----	-0.0007 (0.0008)	-----	-0.0001 (0.0003)	-----	-0.0007 (0.0007)
REGCMP	-----	0.0026* (0.0015)	-----	0.0001 (0.0006)	-----	0.0026* (0.0015)
REGUBN	-----	0.1559 (0.1207)	-----	-0.1379*** (0.0505)	-----	0.1559 (0.1207)
CM PUBN	-----	0.0002 (0.0011)	-----	-0.0011** (0.0005)	-----	0.0002 (0.0012)
PREGMPT	-----	-0.0389 (0.0001)	-----	0.0178 (0.0689)	-----	-0.0389 (0.00002)
PREGUBN	-----	-0.0004 (0.0012)	-----	0.0007 (0.0005)	-----	-0.00004 (0.0012)
REGCMUBN	-----	-0.0034 (0.0014)	-----	0.0016** (0.0007)	-----	-0.0034** (0.0014)
PREGCMTUNB	-----	0.00001 (0.00001)	-----	-0.0870 (0.0531)	-----	0.00001 (0.00001)
<b>t_dummies</b>						
t_2001	0.0195 (0.0238)	0.0082 (0.0302)	0.0059 (0.0102)	0.0082 (0.0111)	0.0062 (0.0101)	0.0082 (0.0302)
t_2002	0.0239 (0.0281)	0.0056 (0.0290)	0.0048 (0.0102)	0.0072 (0.0107)	0.0052 (0.0101)	0.0056 (0.0290)
t_2003	0.0348 (0.0282)	0.0178 (0.0294)	0.0121 (0.0103)	0.0111 (0.0108)	0.0126 (0.0102)	0.0178 (0.0294)
t_2004	0.0361 (0.0283)	0.0235 (0.0294)	0.0143 (0.0103)	0.0153 (0.0108)	0.0148 (0.0102)	0.0235 (0.0294)
t_2005	0.0505** (0.0292)	0.0427 (0.0297)	0.0131 (0.0111)	0.0124 (0.0113)	0.0138 (0.0109)	0.0427 (0.0297)
t_2006	0.0567** (0.0294)	0.0489 (0.0301)	0.0159 (0.0112)	0.0128 (0.0115)	0.0167 (0.0111)	0.0489 (0.0301)
t_2007	0.0734** (0.0297)	0.0614** (0.0303)	0.0340*** (0.0114)	0.0345*** (0.0118)	0.0347*** (0.0113)	0.0614** (0.0303)
t_2008	0.0818*** (0.0305)	0.0681** (0.0306)	0.0384*** (0.0118)	0.0397*** (0.0119)	0.0391*** (0.0117)	0.0681** (0.0306)
t_2009	0.0906*** (0.0304)	0.0772** (0.0306)	0.0463*** (0.0118)	0.0479*** (0.0120)	0.0471*** (0.0117)	0.0772** (0.0306)
t_2010	0.0877*** (0.0308)	0.0729** (0.0309)	0.0474*** (0.0120)	0.0485*** (0.0121)	0.0481*** (0.0119)	0.0729** (0.0309)
t_2011	0.0911*** (0.0304)	0.0769** (0.0306)	0.0515*** (0.0118)	0.0519*** (0.0119)	0.0521*** (0.0117)	0.0769** (0.0306)
t_2012	0.0956*** (0.0303)	0.0794*** (0.0305)	0.0567*** (0.0117)	0.0588*** (0.0119)	0.0573*** (0.0117)	0.0794*** (0.0304)
t_2013	0.1000*** (0.0306)	0.0894*** (0.0307)	0.0602*** (0.0120)	0.0617*** (0.0122)	0.0608*** (0.0119)	0.0894*** (0.03071)
<b>Constant</b>	0.9543*** (0.0394)	0.9703*** (0.0941)	0.9119*** (0.0307)	0.9194*** (0.0418)	0.8816*** (0.0405)	0.9703*** (0.0941)
Preferred Model	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect	Fixed Effect
Number of Obs	223	223	223	223	223	223

Note: Significance; \*\*\*:1% level, \*\*: 5% level, \*: 10% level. Standard errors are reported in Parentheses.

## 5.12 Discussion

This section focuses on the individual country technical efficiency based SFA result and our first hypothesis, whatever a country with many electricity distribution companies obtain a higher efficiency level. In other words, frequent electricity interruption affects the technical efficiency and the reliability of power supply in the region. Given the lack of an adequate distribution infrastructure, the electricity delivered to the customers is less than the amount actually generated, because of factors such as damaged power lines, transmission technical losses and high theft of electric power in the region (KPMG, 2015).

### 5.12.1 General Models Analysis and improvement path of inefficient EDISCOs

The average technical efficiency value indicates the overall efficiency of the EDISCOs. Thus if the technical efficiency score equals 1, this signifies that the EDISCOs are efficient. If the score is less than 1 then they are identified as inefficient. The result in table 5.11 indicates that three EDISCOs (Cameroon, Ethiopia, and Uganda) are inefficient as their average technical efficiency level is less than the model specific average (0.89), with the other 13 EDISCOs operating on/or above the average technical efficiency level of 0.895 (*see table 5.11*). These three countries have similar conditions and patterns of system losses in their electricity distribution networks, and we infer that the following could contribute to their below average performance.

Fifteen years after privatisation of the former National Electricity Company of Cameroon (Sonel)<sup>111</sup>, consumers still face an average service with high outages (many households may not have power for days), an outcome which is attributed to insufficient distribution line length (Ossono 2014). The Ethiopian electricity distribution network is largely undeveloped as 85% of the population lives in a rural area without access to the national grid, and only 2 million people live in urban areas with access to electricity. Thus, electricity distribution losses in Ethiopia are high, with an average 21.1% in 2013, which makes the little improvement achieved insignificant (USAID 2015).

The Uganda power distribution sector suffers a similar pattern of system losses, although the private company (UMEME) managing the electricity distribution networks in Uganda has

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<sup>111</sup> An American company AES Sirocco in 2001 acquired the Sonel - Cameroonian National Electricity Corporation and invested over US\$685 million-dollar equivalent of 400 billion CFA in the sector.

made significant progress in bill collection, the billing collection rate being 95.1 percent in 2013. Although the target is to reduce distribution losses to 13.25% by 2018 this is still below the World Bank benchmark of 12% (ERA 2011, 2013).

The technical efficiency scores of each of the countries in Table 4.11 show that there is not much difference between technical efficiency levels in countries with many EDISCOs and others with few/one distribution company.

**Table 5.12:** Efficiency score of all models estimated

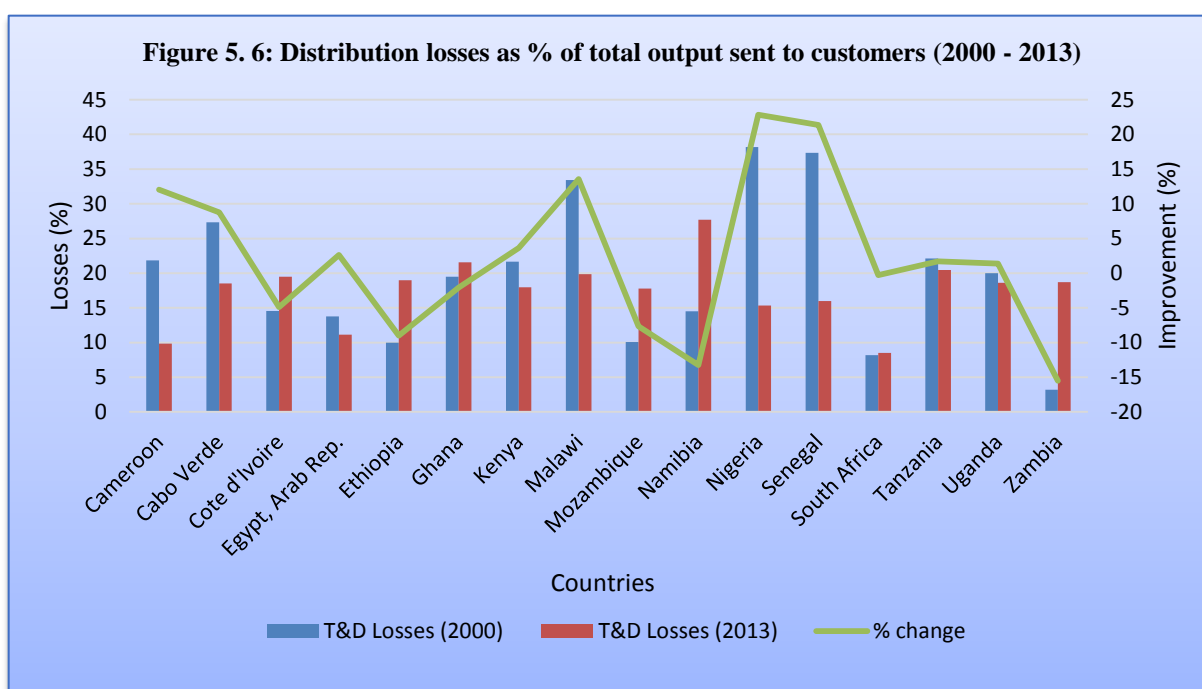
EDISCO	Model 1	Model 2	Model 3	Model 4	Average	No EDISCOs
Cameroon	0.65	0.65	0.73	0.73	0.69	3
Cape Verde	0.99	0.99	0.99	0.99	0.99	9
Cote d'Ivoire	0.98	1	0.87	0.87	0.94	1
Egypt	0.99	0.99	0.99	0.99	0.99	9
Ethiopia	0.88	0.88	0.86	0.86	0.87	1
Ghana	0.96	0.99	0.76	0.99	0.93	2
Kenya	0.87	0.87	1	1	0.94	1
Malawi	0.99	0.99	0.99	0.99	0.99	1
Mozambique	0.99	0.99	0.99	0.99	0.99	1
Namibia	0.97	0.99	0.99	0.99	0.99	4
Nigeria	0.96	0.96	0.94	0.94	0.95	11
Senegal	0.90	0.99	0.99	0.99	0.94	1
South Africa	0.99	0.99	0.99	0.99	0.99	187
Tanzania	0.91	0.91	0.98	0.99	0.95	1
Uganda	0.62	0.62	0.99	0.95	0.80	1
Zambia	0.98	0.98	0.99	0.99	0.99	2
<b>General average</b>	<b>0.89</b>	<b>0.89</b>	<b>0.90</b>	<b>0.90</b>	<b>0.90</b>	<b>235</b>

**Source:** Authors calculation based on estimation using STATA 13

### 5.12.2 Benchmarking of Selected Countries in the Region

In advanced economies electricity distribution networks report from 3% to 10% in distribution losses, and exhibit constant returns to scale. In the case of African countries, the majority of the countries have distribution losses of up to 22%, leading to a greater inefficiency in electricity distribution. Figure 4.6 shows distribution losses in the region are evenly distributed, with the mean level of losses at 19.72% and 17.52% and the median level at 21.75% and 18.81% in the year 2000 and 2013 respectively. Countries with losses beyond

the 20% benchmark<sup>112</sup> in 2013 are Ghana (21.55%), Namibia (27.72%) and Tanzania (20.45%). The countries with losses below the 20% benchmark in 2013 are Cameroon (16.05%), Cape Verde (18.53%), Cote d'Ivoire (19.47%), Egypt (11.14%), Ethiopia (18.98%), Kenya (17.98%), Malawi (19.84%), Mozambique (17.77%), Nigeria (15.34%), Senegal (15.98%), South Africa (8.49%) and Zambia (18.6). Countries in the region that have not adopted reforms in their distribution sector have higher distribution losses that exceed the benchmark. The green trend in figure 4.6 shows the percent change in the distribution losses achieved by a country over time.



**Figure 5.6:** Distribution losses as % of total output sent to customers (2000 - 2013)

**Source:** Author's construction based on data from World Development Indicator, Africa development indicators, and EIA

<sup>112</sup> The 20% benchmark is used by the World Bank as good performance indicator for developing countries and it is calculated as 10% (for technical losses) and another 10% (for non-technical losses, often referred to as commercial losses).

### 5.13 Conclusion

Efficiency and benchmarking analysis are essential tools used in network utilities research and the regulatory context, especially in testing the impact exogenous factors have on electricity distribution companies' performance or the choice of relevant models. In this chapter we have presented an empirical analysis of the effect of *peak load* and *customer density* on the performance of sixteen African countries electricity distribution companies. The African region is a suitable case for such a study because of its large number of EDISCOs, and the desire to improve its electricity market through market-oriented reforms of the sector.

This is the first attempt to measure technical efficiency of electricity distribution companies in the region. This study shows that technical efficiency does not depend wholly on firm size or the number of electricity distribution companies a country possesses, but rather that the presence of a regulatory body in a country can influence the quality of service, which directly affects technical efficiency.

In addition, African countries stand a better chance of improving the quality of service, ensuring a reliable power supply and a reduction in the percentage of distribution outages if they adopt at least three reforms.

We believe that our results may be improved upon with the availability of more data, especially data on energy sold (MW), bill collection data, the amount of illegal connections and data on the time it takes the distribution operatives to response to outages in the region.

Overall, the result suggests that *the amount of energy delivered*, *the number of customers*, *the number of transformers* and *the number of employees* are relevant input and output variables in measuring technical efficiency of electricity distribution companies. Moreover, the difference between technical efficiency levels of countries with many EDISCOs and others is only slight. The time effect in the SFA-IDF models implies that we need to be aware time-invariant inefficiencies may be embodied in the efficiency score of EDISCOs, which is important for ranking firms and use in regulatory benchmarking.

## Chapter 6

### **Similar situations, different Outcomes: Explaining the factors influencing PPPs-Investment inflow in the African Electricity Market**

#### **6.1 Introduction**

Having examined the extent to which some African countries have improved technical efficiency in their electricity distribution sector in the previous chapter, this chapter seeks to explain why some countries in the region attract more public-private partnership (PPPs) investments than others in the electricity market. Why are PPPs the dominant form of investment in the electricity supply industry nowadays, especially in developing countries? Why is it that certain forms of PPPs are common in the sector? And how have different reforms/economic policies impacted on attracting PPP investment in the electricity supply industry in the region? Answering these questions gives us an insight as to why PPP's are considered the better option (especially for developing economies).

The introduction of PPPs in developing countries could not be attributed to internal processes. Rather, it is a child of coincidence based on the Washington Consensus<sup>113</sup> and shared by some international private entities and a set of developing countries that consider PPPs as the best option to improve power sector infrastructure. The main justification, as recorded in the literature, is due to the lower cost, greater efficiency and higher quality of service delivery provided by private participation over the public (Vaillancourt-Rosenau, 2000 and Hammami et.al. 2006).

Despite the adoption of market-oriented reform in the power sector, invariably supported by the World Bank and other donors, there seems to be different patterns in the inflow of PPP investment and the number of projects among developing countries. This trend is weaker in low-income countries such as Sub-Saharan Africa, compared to other developing countries.

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<sup>113</sup> The Washington Consensus refers to a set of economic policies designed specifically for developing countries. It was sponsored by two Bretton Woods institutions (World Bank and International Monetary Fund). For more details on the Consensus see [Stiglitz (1998); Gore (2000); Williamson (2000) and Rodrik (2006)].



East Asia and the Pacific, Eastern Europe and Latin America attract more power sector projects and higher investment values than the African countries.

Although most of the countries in Africa have involved the private sector in their electricity sector, such projects have had mixed results, especially when compared to other developing regions. It is estimated that the African region needs 7000 megawatts (MW) yearly to meet its energy demand by 2020 (World Energy Outlook, 2014). It requires investments of up to \$27 billion annually. Presently, the combined installed capacity in the region is not sufficient to meet this demand, thus there exists the possibility to partner with the private sector to attract meaningful PPP, so as to address the gap in the power sector investment shortfall (UNECA, 2014 and Eberhard and Shkaratan, 2012).

Using data from the World Bank PPP database, the World Development Indicators, African Development Indicators, Worldwide Governance Indicators, the Enterprise Survey and the US Energy Information Administration, we construct a panel (unbalanced) data analysis of private investments and the frequency of power projects in the electricity sector in twenty-eight African countries. Relaxing the standard assumption regarding the determinants of investment in infrastructure sectors, we analyse the impact of variables that represent differential institutional capacities, good governance factors, macroeconomic conditions, and economic reform policies on a country's ability to attract public-private investment into the power sector.

To achieve the above objectives, this study seeks to answer the following questions:

- i). To what extent does market-oriented reform matters in attracting private sector participation in electricity market in developing economies?
- ii). Do African countries with strong political institution structure (such as a strong judicial system, a low corruption rate, and adherence to the rule of law) can reduce investment uncertainty and promote higher private sector participation?
- iii). Do macroeconomic stability (*i.e. low inflation, access to capital*) promotes increase in private sector investment in African electricity market?

The reform experience in the power sector among the developing countries is based on the notion that the key objective is to change the institutional and structural framework of the industry, so as to enable the operator to enhance their performance and be more efficient. Since the Chilean experience in the early 1980s, the implementation of reform in the power

sector has become a prerequisite for the main donors such as the World Bank and IMF, before the granting of loans or the providing any form of assistance (Bigsten and Mutailenwa, 1999). However, although the content of power sector reform differs from country to country, there are similar/common patterns/sequences in restructuring such as establishing independent regulatory agencies, privatisation of the sector (so as to permit greater private participation in the industry), and introducing competition (especially in power generation and retail).

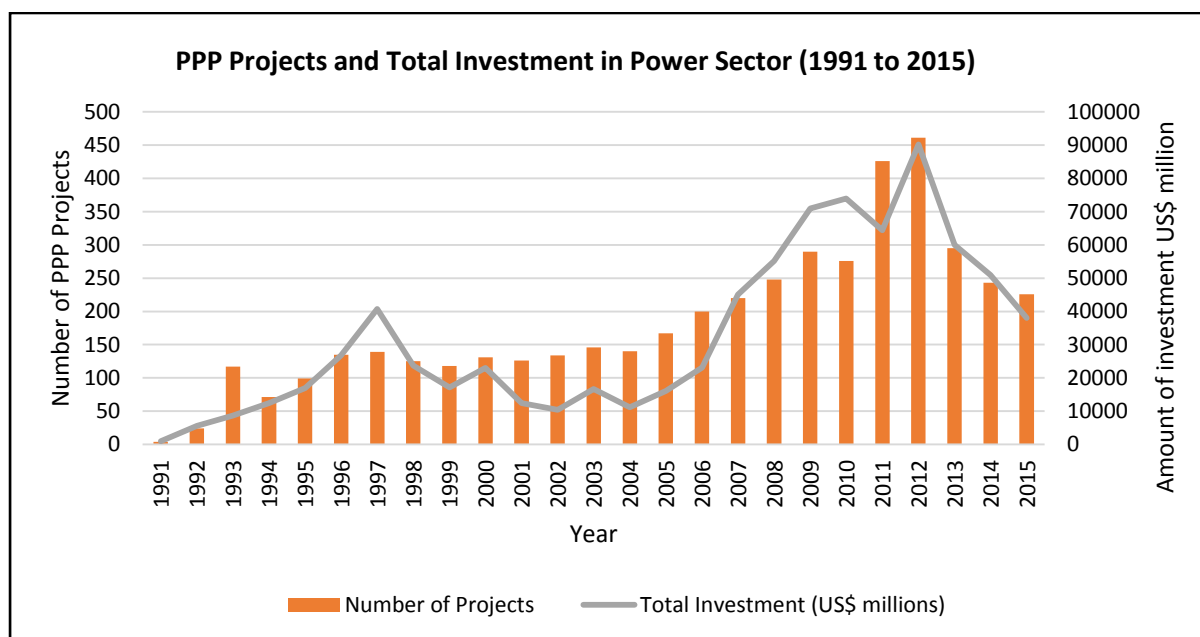
To the best of our knowledge this study constitutes one of the few empirical attempts to discuss and analyse the drivers of PPP investments in the power sector in the African region.

This chapter is organised into the following sections. In section 6.2, we discuss the PPP in the power sector, with a focus on the types of PPP. In section 6.3, we briefly summarise African experience of PPPs in the power sector. Section 6.4 deals with the conceptual framework and provides the literature review. Section 6.5 deals with the methodology and model specification and Section 6.6 presents the preliminary evidence. In section 6.7 we specify the estimation and empirical results and the section 6.8 deals with Robustness check, lastly section 6.9 draws the discussion and conclusion.

## **6.2 Public-Private Partnership in Electricity Market**

Prior to the early 1980s, many developing countries (including African countries) advocated import-substitution industrialisation and industrial protection policies. However, over the past three and a half decades there has been a shift in economic policy in many countries in the African region. This led many to undertake restructuring/reforms in their power sectors to enhance the quality of service, to increase electricity access to their populace, and to improve management efficiency in the industry. However, the governments in the region were constrained by limited fiscal resources, capital shortages and the mismanagement inherent in the state-owned enterprises/corporations (SOEs). Increasing population in the region, which gave rise to a higher demand for electricity, saw governments seek greater involvement of the private sector in the delivery and financing of power generation, transmission and distribution as a quicker means to solve the problem. This was encouraged by multinational institutions such as the World Bank, the International Monetary Fund, the African Development Bank, and other bodies from EU, United Kingdom, and the United States (Kirkpatrick et al, 2006, Biglaiser and DeRouen, 2006).

Public-Private Partnerships in the power sector have grown substantially since 1991, with the number of electricity projects concluded attracting further private investment (see *figure 6.1*). The figure, below shows significant progress made in both the number of projects executed and the value of investments made in the sector, with the number of projects oscillating between 120 and 460 per year since 1996<sup>114</sup>.



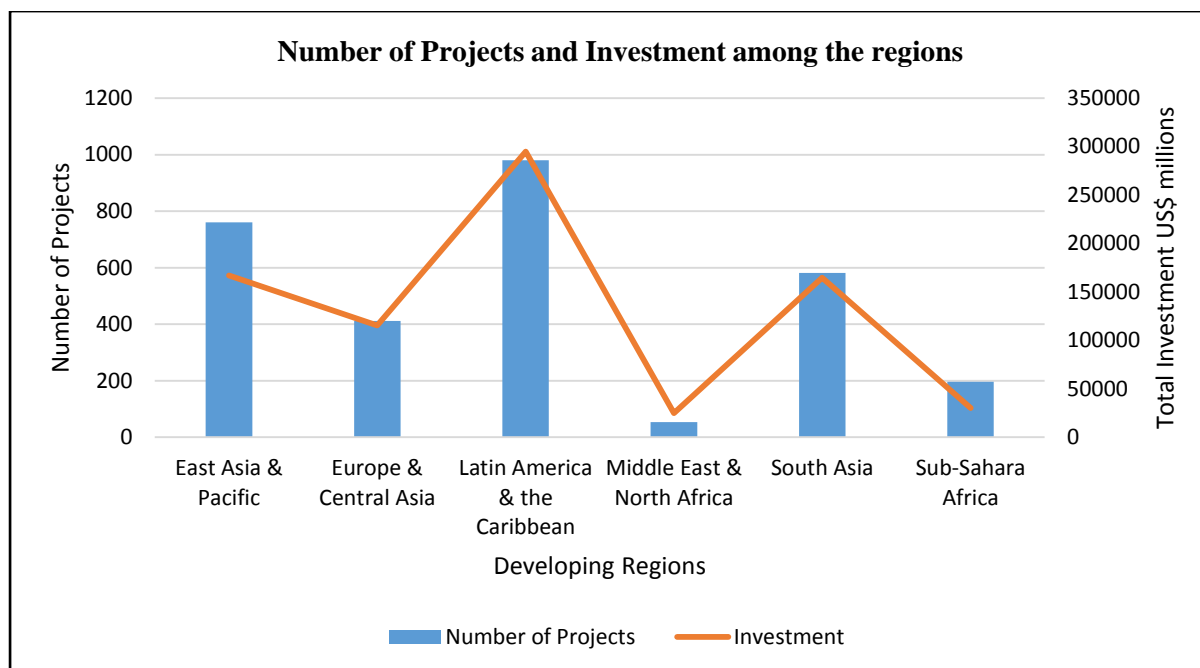
**Figure 6.1:** World Trends for PPP Projects and Total Investment from 1991 to 2015.

**Source:** World Bank and PPIAF, PPI Project Database

Overall, investment commitments reached a peak in 2012, with countries in Latin America, East Asia and the Pacific accounting for 33 percent and 25 percent respectively in terms of the number of projects, and 37 percent and 20.9 percent of all the PPP investment in the power sector.

Private sector participation in the power sector take different forms. Thus, PPPs could be sub grouped into four models in which the private entity engages in either designing, building a new power plant, or refurbishing or expanding an existing one. The type of PPP investment that dominated the market is the Greenfield type (70.9 percent of number of projects and 15.8 percent of the 125,607 projects attributed to divestures in the sector between 1991 and 2015 (see *Table 6.2*).

<sup>114</sup> Although there was decline in 1994 in terms of number of projects and in the value of investment in after 2012, which shows a 20.2% increase in value of investment in 2012, compare to 2013.



**Figure 6.2:** Number of Projects and Investments among the regions

**Sources:** World Bank and PPIAF, PPI Project Database

Management and lease contracts have been rare in the electricity market compared to other investments. Management and operation contracts with foreign or local firms to manage the sector contribute just 0.07 percent of the 796,877 projects.

### 6.2.1 Patterns of PPP Activity

Across the developing countries, public-private partnership in the power sector accounts for more than 60 percent of infrastructure investment in the power sector. The most revealing of the data relates to the variation in the number of projects and the value of investment attracted by different developing regions (Table 6.2). Initial growth in PPPs in the power sector was driven by the Latin American countries' readiness to involve the private sector.

In the early 2000s, there was an increase in PPP growth in other developing regions, especially in power generation. The PPP bias towards middle income developing countries such as the Latin America region has been confirmed in a number of studies. IMF studies found that countries with a large population, with a strong rule of law, political stability, high energy consumption and stable macroeconomic indicators benefitted most (Trebilcock and Rosenstock, 2014; Hammami, Ruhashyankiko, and Yehoue, 2006).

**Table 6.1: A Typology of PPPs Projects in the Power Sector**

<b>PPPs Type</b>	<b>Description</b>	<b>Sub-Type</b>
<b>Brownfield Concession</b>	Refers to when a private firm takes over the management and operation of a state-owned enterprise, in a bid to extend, complete, or rehabilitate the facilities to be more efficient and profitable. The private firm bears the risk involved and benefits from the yields. Brownfield concessions are normally for a specific period of time.	ROT – Rehabilitate, operate and Transfer
		RLT – Rehabilitate, lease/rent, and transfer
		BROT- Build, rehabilitate, operate, and transfer
<b>Greenfield Concessions</b>	It captures a situation when a private entity builds and operates a facility for a period of time, as agreed with the state-owned enterprises.	BLT – Build, lease, and transfer
		BOT - Build, operate, and transfer
		BOO – Build, own, and operate
<b>Management and Lease Contracts</b>	When a private firm agrees to manage a state-owned power utility for a specific period of time (and terms and conditions apply). Here the government shares the risk involved and the benefit with the private firm (depending on sharing ratio underlying the contract).	Management Contract
		Lease contract
<b>Divestiture</b>	This is the transfer of ownership of a state-owned enterprise to a private firm. This process could see full-private ownership, or partial ownership.	Full Ownership – the entire facility is sold by the government.
		Partial Ownership – Government retain some percentage of the ownership of the utility.

**Table 6.2:** Type of PPPs Investment in the Power Sector (1991 to 2015)

Regions	Brownfield	Divestiture	Greenfield	Management & Lease Contract	Total
East Asia & Pacific	7071	21897	137875	0	166,843
Europe & Central Asia	16017	55760	43698	92	115,567
Latin America & the Caribbean	72482	35555	186657	210	294,904
Middle East & North Africa	6607	224	17943	0	24,774
South Asia	342	10470	153662	286	164,760
Sub-Sahara Africa	2755	1701	25568	5	30,029
Total	105274	125607	565403	593	796,877

**Sources:** World Bank and PPIAF, PPI Project Database

### 6.2.2 The difference between PPP-Investment and Private Investment in the Electricity Market

The fundamental difference between the PPP-investment and private investment in the electricity market is mainly in the contracts structure and risk involved. Whereas, private sector investment is the total transfer of ownership of public utilities assets permanently to a private firm(s). This form of ownership could be in different form, the notable example is the divestiture (see table 6.3)

**Table 6.3:** Responsibilities and Role of Public and Private sector under different form of PPP-Investment

Option From	Concession	Management/ Lease Contracts	Divestiture
Asset Ownership	Public/Private	Public	Private
Operation and Maintenance	Private	Private	Private
Capital Investment	Private/Public	Public	Private
Commercial Risk	Private	Public	Private
Duration	5 – 10 years	5 – 10 years	Long -terms

Divestiture in electricity market reform is generally considered to be an instrument of competition, because it impacts on both the management and ownership structure of the public utilities, thus it is a full private sector participation in electricity market (Green, 1996). However, for PPP-investment, the government-owned public utility shared some responsibilities and role with the private sector firms. In other word is a system where public or state- owned entity and private sector entity shared the provision of public assets and/or related

services for general public benefit, through asset ownership, operation/maintenance, investments being made by and/or management undertaken by the private sector entity for a specified period of time, where there is a substantial risk sharing with the private sector.

### **6.2.3 Reasons for Private Sector Participation in Electricity Market Reform**

There are two approaches to assess the effects of liberalisation reforms on PPP-investment in electricity market. First, to examine private investment in conjunction with public investment (i.e. the ratio of private investment over a total investment in the sector) or secondly, examine the novel metric (confidence measure) that promotes public sector to attracting private investment in the electricity market. These two approaches can provide insights to the effects of market-oriented reform on PPP-investment performance in the electricity market.

However, in each case, it is important to consider the availability of reliable data. The unavailability of sufficient data on public investment in electricity market in developing countries makes it “hard” to use the first approach.

In the light of historical experience, private sector investment in electricity market reform in developing countries is a sign of response to incentives and risk return trade-off in the industry. Government commitment and regulatory framework in the industry contribute significantly to attracting private investors to the industry. The economic crisis, debt burden, poor electricity supply and a lot more in the early 1990s led many developing countries to opening up of their electricity market for private sector participation (IEA, 2003). However, the investment atmosphere was further strengthened by introducing liberalisation policy to the state-owned power utilities, countries started by amended their electricity law to enabled privatisation, competition in the sector and improved the quality of power supply. Also, some others established regulatory agency to monitor and protect the private sector investments. Some of the countries like India went further to abolished the single buyer model, and thereby increases the level of private sector participation in the industry.

### **6.3 The Africa Electricity Market and Private-Public Partnership Investment Flow trend**

In the 1990s, there was a policy shift from a Keynesian presumption that essential services (such as the provision of electricity) are best delivered by the state, toward the Hayekian assumption that favours granting opportunities to the private sector to share the risk and benefits involved. The Hayekian notion was based on the fact that state involvement leads to greater failure. The electoral victories of Margaret Thatcher and Ronald Reagan in the United Kingdom and the United States of America, respectively, the collapse of the Soviet Union, and the advances in technological innovation in the telecommunications industry marked a turning point, as developed countries authorised the greater participation of the private sector in provision and management of essential services. Decision-makers and leaders in Africa, however, were less prepared to embrace such change, unlike their counterparts in Latin America and the ex-communist countries, who readily bought into the new paradigm of private sector participation in the provision of essential amenities (Nellis, 2005).

The general factors that motivate developing countries governments to seek PPPs could be summed up as: first, replacing poorly performing state-owned enterprises (SOEs) with private counterparts whose main aim is to reduce waste and maximize profit, thus leading to improved delivery of service and a reliable power supply. Usually, this involves changes in technical and managerial capacity, brought into the sector by the private operative. The second motivation is a sharing of the risk involved. The desire to allocate part of the risks and benefits to the private sector see developing countries' governments keen to involve the private sector. Third, governments may seek PPPs as a means of satisfying the growing demand, without compromising due to budget constraints, and to also fulfill political promises (Trebilcock and Rosenstock, 2015).

PPPI started slowly in Sub-Saharan Africa, with 25 projects between 1991 and 1993, rising to 70 from 1994 – 97, and to 140 projects from 1998 to 2003. However, these represented only 6.3 percent of the total number of electricity projects sponsored through PPPs in the developing countries.

Nonetheless, of the 2,983 PPPs projects concluded in the power sector between 1991 and 2015, 196 were shared among over 40 different countries in Sub- Sahara Africa. 60 of those projects are located in South Africa (our study excludes Swap-PPP's in the region that were

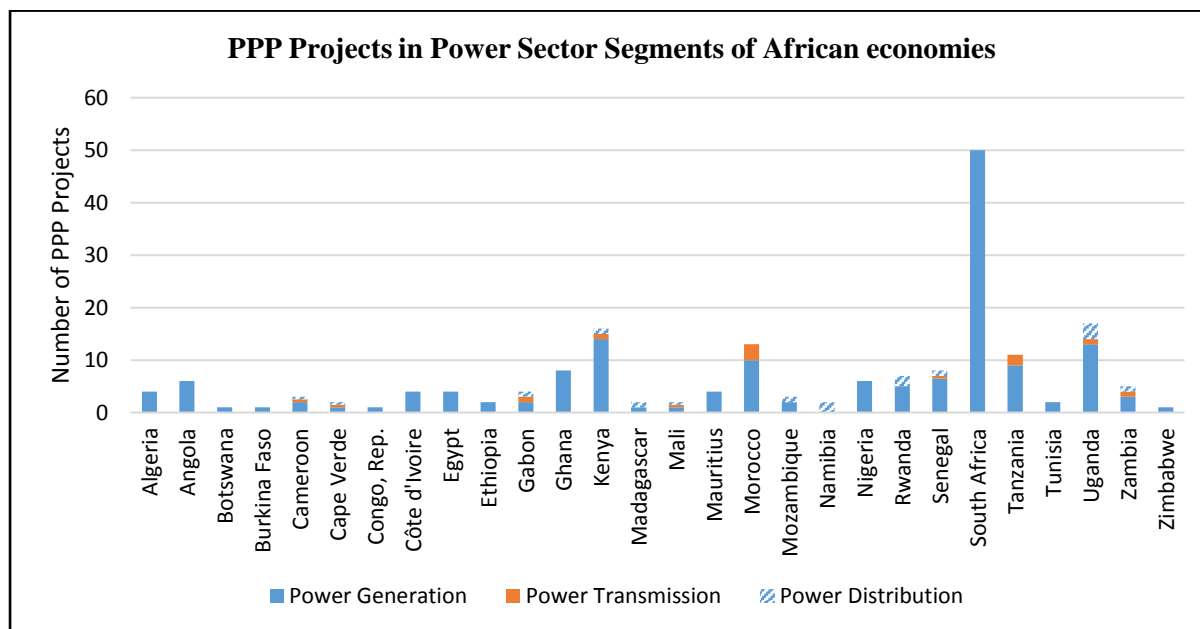


conducted in exchange for natural resources with some countries such as Angola, Congo DR, and Zambia and China).

### 6.3.1. Private Sector Investment in the Electricity Market in Africa

The current capital investment in Sub-Sahara Africa's power sector (from all sources) is approximately US\$4.6 billion per year, which is below the US\$26.7 billion recommended by the World Bank (UNECA, 2011). The private sector contribution is relatively less than the current amount, because private investors prefer thermal generation, rather than developing hydropower. Moreover, governments' efforts at involving private sector to rural electrification projects were not successful, due to the low return on such investment (UNECA, 2014).

Historically, the main sources of investment in the power sector in Africa are the government and donor agencies. In recent years, these sources of funding have declined. Thus one alternative funding source are the PPPs. Equally, the variation in the number of projects and the value of investments in power generation is noticeable, with over two-thirds of the PPP projects and investments in the generation segment, while the remainder is shared between the distribution and transmission segments (*see figure 6.3*).



**Figure 6.3:** PPPs Projects in power sector segments of African economies (1991 to 2015)  
Sources: World Bank/PPIAF database (2015)

The fewer projects in transmission and distribution sectors could be attributed to the nature of the sector, which is often characterized as a natural monopoly, including economics of scale and scope, and sunk costs, which private investors may not be willing to bear. In the transmission segment, some countries in the region (such as Nigeria) only involve private sectors in the form of management contract. While in the case of the distribution segment, the opposition of unions and political considerations may be factors for low private sector participation. Among the projects executed in the electricity distribution and transmission sectors were five natural gas-fired power plant projects<sup>115</sup> (valued at US\$ 2.2 billion), some of which are close to completion, while others have various phases of the project completed (UNECA, 2011).

As shown in figure 6.3, between 1991 to 2014, the Republic of South Africa (50) has the highest number of projects among the countries in the region, with Uganda (16), Kenya (16) and Morocco (13) following. The process of introducing private sector participation in the industry varies across countries in terms of strategy, pace, sequence and its scope. A number of countries in the region (such as South Africa, Morocco, Nigeria, Uganda and Kenya) have allowed the private sector (independent power producers) access to their generation segment, while transmission and distribution remain under state control. Other countries in the region have allowed private sector participation in both generation and distribution segments, such as (Morocco and South Africa).

#### **6.4 Conceptual framework, literature review and Hypothesis**

The theoretical framework underpinning the public-private partnership in the electricity market is based on the theory of X-efficiency developed by Leibenstein (1966). He is of the opinion that public institutions and state-owned enterprises are inefficient because of government intervention. X-inefficiency among SOE is as a result of a lack of competition and the market structure, while such SOE are also highly bureaucratic, giving rise to a need for private sector participation in the industry if efficiency is to be improved.

In the study of electricity market reform, the role of institutions/government commitment, economic reform strategies and macroeconomic stability have attracted the interest of both theoretical and empirical analysts. Therefore the critical question is why are African countries

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<sup>115</sup> The Biskra Gas-fired Power Plant (Algeria), the Sidi Krir 1 Power Plant (Egypt), the Sunon-Asogi Gas-fired Power plant (Ghana), the Azura-Edo Gas-fired power plant Phase 1 (Nigeria) and the Songas-Gas fired power projects (Tanzania).

falling behind in attracting public-private investment inflows into the power sector when compared to other developing countries? (It is important to note that this study focuses on “attracting PPP Investment” rather than “reform success”).

Previous studies have linked the increase in PPP investment to the type of government in power (Jensen 2002, 2003; Li and Resnick, 2003), to low corruption rates (Mathur and Singh 2013; Biglaiser and Danis 2002), to political stability, to policy credibility and to the establishment of a regulatory framework which lowers the perceived risk of expropriation in the industry (Kerf *et al.* 1998, Pargal, 2003 and Holburn and Zellner, 2010). Institutional frameworks, for instance judicial strength and the rule of law, are also important (Staats and Biglaiser, 2012, Levy and Spiller 1994). Investors are most likely to invest in countries with secure property rights, strong political institutions, and political stability so as to minimise the investment risk.

## **6.5. Factors contributing PPP Investment inflow into the Power Sector**

We identify four major factors that influence PPP investment flows:

### **6.5.1. Market-Oriented Reform**

Economic policies in the form of market-oriented reform have a significant effect on electricity market performance. It is effective, due to the nature of the industry, for the government to establish an independent regulator to monitor and direct the activities of the operators (firms). Establishing a regulatory body is key in attracting private sector investment (Pargal, 2003). Wallsten (2002) suggested that countries with independent regulatory institutions in place before privatisation experienced an increase in private sector investment.

Moreover, the monopolistic nature of the market is a thing of concern to the government, and most governments in the region have introduced competition by allowing private sector participation (especially in power generation and gradually in the distribution sector). Therefore, we hypothesise that:

**Hypothesis 1:** *Market-oriented reform in the form of regulation, privatization, competition and unbundling is positively associated with private sector investment in the electricity market in African economies.*

### 6.5.2 Government Commitment

This is a critical factor for successful attraction of PPP. The incumbent governments in the region have to attract private investors to invest in the power sector. In fact, due to the capital-intensive nature of the industry with its large sunk costs, the government should amend existing Electricity Acts to enable greater private sector participation. For instance, the power sector reform in Great Britain can be attributed to the then Conservative Party government of Margaret Thatcher, which revalorized the entire electricity market system. It was the first attempt to apply reform insights on a large scale and it is often regarded as the 'standard text book model' of electricity sector reform (Victor and Heller, 2007). Similar ideological principles and political commitment aided the reform of the power sector in both Norway and New Zealand (Bacon and Beasant-Jones, 2001).

On the contrary, any country that is characterised as unreliable, unstable, corrupt and/or ineffective will experience affliction in attracting a private sector participation (Howell, 1998). Given the nature of investment in this industry is long-term, with sunk costs, and as most of the projects are irreversible and non-tradeable, investors consider government commitment in the host country before committing to invest. The risk of nationalisation, expropriation of assets, conflicts and inability to repatriate profits can force the private sector, to either cancel or withdraw totally from such projects (Henisz, 2002a; 2002b). In other words, a region or country with an effective bureaucratic structure, rule of law, a political stable environment, democracy, and less corruption is likely to attract more private sector investment in its electricity market. Dethier et al (1999) reported that countries with a democratic system of government is more likely to adopt market-oriented reform, which in turn facilitates an increase in private sector participation. Based on the above, we developed the third hypothesis.

**Hypothesis 2:** *Corruption, political instability, and governmental ineffectiveness are negatively associated with public-private partnership in electricity market investment in African market.*

### 6.5.3 Institutional Capacity

The role of strong and efficient institutions cannot be overemphasised in attracting investment to the power sector in developing countries, especially in the African region. Scholars such as North (1990), Sherwood, Shepherd and Macrcos de Souza (1994), Brunetti,

Kisunko, and Weder (1997) emphasised the role of courts and the rule of law for accelerating inward investment. Institutions also refers to formal and informal rules that constrain the actions of individuals, firms and government corporations (North, 1990). Institutions reduce uncertainty in the system (North, 1991). This idea has been incorporated into empirical studies as one of the key determinants of foreign direct investment in developing countries. Scholars such as Altomonte (2000) and Morisset (2000) include variables in their studies to control for institutional differences across countries. Developing countries that have achieved an increase in PPPI in the power sector are hypothesised to be those with a system which protects private investment and a mechanism that effectively enforces the law, (i.e. if a contract is cancelled, full compensation is paid without any bureaucratic delay). No matter the parties involved this leads to a conclusion that weak institutions are a threat to increased PPP inflows into the power sector in developing countries (Lamech and Saeed, 2003). An independent regulatory body is another factor that signals to investors a commitment (and credibility) to protect the capital and revenue of the investing private firms.

Figure 6.4 shows the relationship between the institutional framework and market-oriented reform in the power sector. As revealed by figure 6.4 the institutional structure of a country in the process of implementing a reform in the industry is important. One key component of the institutional framework is efficacy of the legal system, and its ability to protect and guarantee the security of investors against unnecessary government interference in the system. There is empirical evidence that countries with strong institutional frameworks, strong legal, and property rights systems perform better in attracting private investment into their electricity market (Knack and Keefer, 2005, De Soto, 2000). Thus, we hypothesise that:

**Hypothesis 3:** *The Institutional framework is positively associated with an increase in public-private partnership investment in African electricity markets.*

#### **6.5.4 Macroeconomic Stability**

Investment in the power sector is considered as a long term commitment by investors, as the return on investment is over the life span of the project. Therefore, stable macroeconomic policies are necessary to attract PPP investment into the power sector. As most of the investment is denominated in US dollars, whereas power purchase agreement payments (the main source of revenue) are denominated in local currency, private sector investors are exposed to currency risk.

High level of economic/financial instability hinders private sector participation in the industry. This instability can be in the form of volatility in the exchange rate and or inflation, as both have a negative impact on private sector investment in the electricity market (Aizenman, and Marion, 1995). Ghura and Hadjimichael (1995) identified macroeconomic uncertainty and instability as the factors responsible for low investment in sub-Saharan Africa. Using indicators such as inflation, exchange rates, fiscal policy and structural and institutional variables, their findings suggest that macroeconomic uncertainty is negatively associated with private investments in the region. Therefore, we conclude with the fourth hypothesis that:

**Hypothesis 4:** *Macroeconomic instability is adversely associated with public – private partnership investment in electricity market projects among African countries.*

## 6.6. Methodology and Model Specification

This study seeks to establish the relationship between dependent variable and the explanatory variables and control variables, for 28 African countries over a period of twenty-five years (1990 – 2014). The time period and number of countries in our study are determined by the availability of data.

We employed a panel data analysis similar to the (*chapter four method*), different in the sense that due to missing observation in the data we have an unbalanced panel<sup>116</sup>. The regression equation below to analyse the impact of political institutional/government commitment indicators, market-oriented policy, and macroeconomics stability variables on private sector investment in African electricity market.

$$Y_{it} = \beta_1 + \sum_{j=2}^k \beta_j X_{jit} + \sum_{p=1}^S \gamma_p Z_{pi} + \delta t + \varepsilon_{it}, \text{ where } t = 1, \dots, T \quad [6.1]$$

In the model,  $Y_{it}$  is the dependent variable (net private sector investment in electricity market per population),  $i$  and  $t$  represent a unit of observation and time period respectively.  $j$  and  $p$  are indices used to differentiate between observed and unobserved variables.  $X_{ji}$  and  $Z_{pi}$  represent observed and unobserved variables respectively.  $X_{ji}$  includes both reform indicators and control variables. Because the  $Z_{pi}$  variables are unobserved, there are no means of obtaining information about the  $\sum \gamma_p Z_{pi}$  component of the model. For convenience, we introduce a term  $\alpha_i$ , known as the unobserved effect, representing the joint impact of the  $Z_{pi}$  variables on  $Y_{it}$ . So, our model may be rewritten as follows:

<sup>116</sup> We entered zero where there is missing observation, which makes the common factors smooth in the time domain and make it balanced.

$$Y_{it} = \beta_1 + \sum_{j=2}^k \beta_j X_{jit} + \alpha_i + \delta t + \varepsilon_{it} \quad [6.2]$$

The  $\alpha_i$  element is vitally important in this analysis. If our control variables are so comprehensive that they capture all relevant characteristics/features, there will be no relevant unobserved characteristics. In that case, the  $\alpha_i$  term may be dropped and pooled data regression (OLS) will be used to fit the model, treating all the observations for all time periods as a single sample. However, since we are not sure whether the control variables in our models capture all relevant characteristics of the countries, we cannot directly carry out a pooled data regression of Y on X. If we were to do so, it would generate an omitted variable bias. Therefore, we prefer to use either a Fixed Effects (FE) or Random Effects (RE) regression. In the FE model, the country-specific unobserved effects ( $\alpha_i$ ) are assumed to be the fixed parameters to be estimated. In the RE model, the country-specific effects ( $\alpha_i$ ) are treated as stochastic.

### 6.6.1 Classification of Sample Countries

In the Table, below, the 28 countries have been divided into three groups, based on their income levels. (We also provide results with and without South Africa).

### 6.6.2 Dependent Variable (Y)

Data on the dependent variable are extracted from the World Bank's PPIAF database electricity sector. The dependent variable is the real total net private sector investment in the electricity sector. We converted the nominal value of the total net private investment into real term by dividing by a GDP deflator (2000) based on US dollars. We also transformed the variable with a natural logarithm. Although a better dependent variable would be private sector investment in the electricity sector as a share of GDP, this was impossible due to missing data for many of the countries (*see the table 6.4 for the average variables summary statistics of the variables*).

In addition, we apply a score factor by subtracting the log of real private sector investment in the electricity industry with the log of size of population of each of the country. Our dependent variable is the **log of real private sector investment per capita**.

**Table 6.4:** Classification of 28 African Countries according to income levels (2014)

Low Income	Lower Middle Income	Upper Middle Income
Burkina Faso	Egypt	Algeria
Ethiopia	Morocco	Angola
Madagascar	Cameroon	Botswana
Mali	Cape Verde	Gabon
Mozambique	Ghana	Mauritius
Rwanda	Kenya	Namibia
Senegal	Nigeria	South Africa
Tanzania	Zambia	Tunisia
Uganda		
Zimbabwe		

**Source:** World Bank/ PPI Database

### 6.6.3 Explanatory Variables ( $X_i$ )

Each of the explanatory variables that was chosen represents a factor that is considered to determine PPP Investment in the sector.

*Market-oriented policy (economic reform)* variables encompass the most common economic reforms initiated by the World Bank and other donors and policy makers in developing countries. These include establishing an independent regulatory body (**Regul**), privatisation of the state-owned enterprise (**Privtz**), creating competition for the state-owned vertically integrated firms (**Compt**) and separation of the different power sector entities (**Unbund**). We measured these indicators in percentages except for regulation and unbundling, which are dummy variables (see table 6.4). These variables are sources from PPI database for privatization, while regulation, competition and unbundling were derived.

*Political Institutional/government commitment*, are indices identified that may affect the extent of private sector participation in the electricity market. Private sector investors consider: Corruption index—measured as the extent to which public power is exercised for private gain. Captured from 0 to 100, with 0 the most corrupt and 100 the least corrupt (**Corrpt**). Political stability is captured as the perceptions of the likelihood of political instability and/or politically-motivated violence. With 0 indicates most violent and 100 is least violent (**Polst**). Rule of law is measured as perceptions of the extent to which there is confidence in and abidance by, the rule of society. Additionally, 0 was allocated to countries with low rule of law and 100 to countries with high rule of law (**Rulaw**) and Judiciary independence (**Judindp**) captures perceptions of the quality of public services, civil service and its independence from political pressures. A value of 0 indicates countries with low judiciary independence, and 100 the countries with strong judiciary independence. For



Political institution and government commitment matters, we used institutional and governance variables obtained from *World Bank development indicators database* to test on *hypothesis 2* and *3* for its impact on the public-private partnership investment on the electricity sector (*see table 6.4*).

Lastly, we employed the following variables to capture the macroeconomic stability: (i) *Inflation* and (ii) *Access to capital*. Inflation is measured as the percentage of annual growth rate of the GDP deflator (**Infatn**). Access to capital is the domestic credit available to private sector by banks as the percentage of GDP (**Asscap**). For a detailed explanation and description of the variables (*see table 6.4*). In sum, these explanatory variables represent the three factors identified in the literature that matter for the private sector participation in the electricity market.

#### **6.6.4 Control Variables ( $Z_{rt}$ )**

Control variables do not directly have impact on the dependent variable, but may explain some portion of the variation in the real private sector investment per capita in the electricity market in the African economies. The following are the control variables used in this study; (i) *Real GDP per capita* and (ii) *Energy consumption*

Real GDP per capita is used as a prosperity indicator, which maintains that countries with high per capita GDP are more likely to attract more private sector participation in their electricity supply industry (Grosse, 1997). We measure the GDP per capita in US\$ dollar base on year 2000 (**Rgdpcap**). Energy consumption is the amount of the energy used by the both industrial and residential users annually (**Enecons**). Data for this variables were obtained from *World Bank development indicator and US energy information agency*. We expect the private sector investment in electricity market may be affected by real GDP per capita, and energy consumption. Also we did not include any country specific variables in the equation, because it reduces the degree of freedom, thereby affect the power of the tests of hypothesis relating to the parameters of the model.

**Table 6.5: Dataset Variables Description**

<b>Dependent Variable</b>	<b>Unit</b>	<b>Notations</b>	<b>Description</b>
Investment in energy with private participation (constant 2000 US\$)	US \$ dollars	NetInvest	Investment in energy projects with private participation covers infrastructure projects in energy (electricity generation, transmission and distribution) that have reached financial closure and directly or indirectly serve the public. Divided by GDP deflator index (US\$) to convert to real investment in electricity market.
<b>Explanatory Variables</b>			
Regulation	Dummy	Regul	0 =No independent/autonomous regulatory Agency in the respective year 1 =Independent/autonomous regulatory Agency.
Privatization	%	Privtiz	Share capacity of private-owned capacities (%)
Competition	HHI %	Compt	Percentage share of government control as relates to private sector participation in the sector
Unbundling	Dummy	Unbund	0 = Vertical Integration 1= Restructuring through vertical separation
Corruption Index	Percentile Rank	Corrupt	Control of Corruption captures perceptions of the extent to which public power is exercised for private gain, as well as "capture" of the state by elites and private interests. With 0 corresponding to lowest rank, and 100 to highest rank.
Political Stability	Percentile rank	Polstab	Political Stability and Absence of Violence/Terrorism measures perceptions of the likelihood of political instability and/or politically-motivated violence, including terrorism. With 0 corresponding to lowest rank, and 100 to highest rank.
Rule of Law	Percentile Rank	Rulaw	Rule of Law captures perceptions of the extent to which agents have confidence in and abide by the rules of society. With 0 corresponding to lowest rank and 100 to highest rank.
Judicial Independence	Percentile Rank	Judepen	It captures perceptions of the quality of public services, the quality of the civil service and the degree of its independence from political pressures, the quality of policy formulation and implementation, and the credibility of the government's commitment to such policies. Percentile rank indicates the country's rank among all countries covered by the aggregate indicator, with 0 corresponding to lowest rank and 100 to highest rank.
Access to Capital - Domestic credit to private sector by banks (% of GDP)	%	Asscap	Domestic credit to private sector by banks refers to financial resources provided to the private sector by other depository corporations (deposit taking corporations except central banks), such as through loans, purchases of non-equity securities, and trade credits and other accounts receivable that establish a claim for repayment. For some countries these claims include credit to public enterprises.
Inflation	%	Infatn	Inflation as measured by the annual growth rate of the GDP deflator shows the rate of price change in the economy as a whole.
<b>Control Variables</b>			
Real GDP per capita	Constant 2000 US\$	Rgdpcap	GDP per capita is gross domestic product divided by midyear population. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant price using year 2000 U.S. dollars.
Population	Number (total)	Popul	Total population is based on the de facto definition of population, which counts all residents regardless of legal status or citizenship. The values shown are midyear estimates.
Energy Consumption	Kwh (Billion)	Enecons	Electric power consumption by the industrial and residential users annually

## 6.7. Preliminary evidence

In this section, we present preliminary evidence about private sector investment behaviour in relation to reform indicator, political institutions and macroeconomic stability performance in selected African countries. Before proceeding with estimation analysis, we conducted correlation matrix between pairs of explanatory variables used in the regression. Table 6.5 show the correlation matrix of the regressors, and indicates the presence of multicollinearity between political institution/government commitment variables.

### 6.7.1 Overview of dataset and countries comparisons

A summary of individual country data is presented in table 6.6. We simply take the average over the respective years for each of the countries' variables in the sample to evaluate their relative performance.

The share of private investment per capita among African countries was generally higher in Cape Verde (57.9%), Morocco (18.9%), Gabon (14%), and the least in Ethiopia (0.04%), Madagascar (0.03%) and Burkina Fasco (0.02%). It appeared middle income and upper middle income countries maintained higher share of the private sector investment per capita than the low income countries.

Mauritius has experienced relative stability politically, with strong judiciary, adherence to rule of law and high real GDP per capita may be attributed to high private sector investment per capita in the power sector (4.8%), although with low participation in terms adopting reforms variables. With low implementation of market-oriented reform in power sector in Botswana, only 40% private sector ownership in terms of capacities, no competition, as the government control 99.8% of the sector. But over the period, its share of private sector investment per capita has increase by (1.3%) as mainly as a result of strong political institutions influence.

In 1999 Cape Verde privatised the state-owned *Empresa Pública Electricidade e Água* (ELECTRA), with 51% ownership retained, established an independent regulator, with private sector participation in power generation in form of independent power producers, but relatively no attempt to unbundled the sector.

**Table 6.6:** Correlation of the Explanatory Variables

Variables	ASSCAP	COMPT	CORRPT	PRIVTZ	LNENECONS	INFATN	JUDINDP	POLST	REGUL	LNRGDPCAP	RULAW	UNBUND
ASSCAP	1	-0.499	0.565	0.183	0.415	-0.421	0.718	0.369	0.011	0.633	0.578	-0.028
COMPT	-0.498	1	-0.202	-0.042	-0.746	-0.003	-0.307	0.095	0.014	-0.356	-0.176	-0.207
CORRPT	0.5657	-0.202	1	0.014	-0.024	-0.299	0.892	0.762	-0.072	0.465	0.899	-0.192
PRIVTZ	0.183	-0.042	0.014	1	0.131	0.163	0.135	0.086	-0.092	0.176	0.076	0.091
LNENECONS	0.415	-0.747	-0.025	0.131	1	0.225	0.183	-0.249	0.187	0.286	0.013	0.375
INFATN	-0.421	-0.003	-0.299	0.163	0.225	1	-0.288	-0.131	0.228	-0.349	-0.240	-0.011
JUDINDP	0.717	-0.307	0.892	0.134	0.183	-0.288	1	0.674	-0.036	0.592	0.899	-0.063
POLST	0.369	0.095	0.762	0.086	-0.249	-0.131	0.674	1	-0.150	0.484	0.804	-0.299
REGUL	0.011	0.014	-0.072	-0.092	0.187	0.229	-0.036	-0.150	1	-0.280	-0.014	0.318
LNRGDPCAP	0.633	-0.356	0.465	0.176	0.286	-0.349	0.593	0.484	-0.280	1	0.521	-0.004
RULAW	0.578	-0.175	0.899	0.076	0.013	-0.240	0.899	0.804	-0.014	0.521	1	-0.059
UNBUND	-0.028	-0.207	-0.193	0.092	0.375	-0.011	-0.063	-0.299	0.318	-0.004	-0.059	1

**Note:** Those highlighted numbers indicate the presence of multi collinearity among political institutions/government commitment variables

However, Cape Verde has experienced gradual economic growth, with reflective political stability, less corruption, and strong judiciary. The combined effects of these factors has influence the share of private sector investment capita.

Gabon is relatively strong due to rich natural resources which attributed to high real GDP per capita. It embarked on reform with privatisation of state-owned vertically integrated power utility - *the Société d'Electricité et d'Eaux du Gabon* (SEEG), established independent regulatory, separated power generation from other two. The sector has experienced increase in relation to private sector investment capita within the period.

Low-income countries faced low real GDP per capita, and weak political institutions. Embanked on market-oriented reform in the late 1990s, as an economic reform aimed to secure loans, encourage diversification of the economy and stabilisation of the power supply. Ethiopia has experienced low economic growth within the period, coupled with weak institutions, low energy consumption has affected the private sector investment per capita. Although the government unbundled the sector, it has not really attract much private sector investment in the sector as expected.

Burkina Fasco state-owned SONABEL still dominates the sector with little private sector participation. The country characterised with fragile institution, poor real GDP per capita and partial implementation of the reform. Not much has been experienced in this country in term of increase private sector investment.

Similarly, Madagascar, although richly endowed with abundant energy resources, but with poor real GDP per capita, weak institution, averagely corrupted tends to reduce the private sector investment in the sector.

However, what factors and lessons we can draw from these preliminary evidence is that real GDP per capita is the sole determinant of the private sector investment in the region. As middle countries appeared to increase their share of private sector investment by increasing their energy consumption, as result of rise in economic growth. In low-income countries, however, low energy consumption, and poor access to capital sharply reduce the private sector investment. In all, the countries in the sample has experienced an increase in terms of increase in the number of private sector owned capacities in the sector.

**Table 6.7: Average variables summary statistics and country ranking (1991 -2014)**

Country	Netinvcap	Regul	Privtz	Compt	Unbund	Corrpt	Polst	Rulaw	RGDP	Infatn	Judindp	Enecons	Asscap
Algeria	0.0665	0.48	<i>15.24</i>	<b>92.07</b>	0.48	29.603	<i>10.04</i>	24.13	1957	13.54	28.85	24.24	13.56
Angola	0.0012	<b>0.72</b>	50	99.09	0	<b>4.75</b>	19.96	<b>5.96</b>	414.83	26.86	10.02	2.36	8.25
Botswana	0.0129	<b>0.12</b>	40	99.84	0.12	<b>78.3</b>	<b>80.6</b>	<b>67.89</b>	<b>3423.5</b>	8.26	69.86	2.14	19.2
Burkina Faso	0.0002	<b>0</b>	26.8	99.83	0	48.295	38.14	35.08	<b>230.33</b>	2.86	28.88	0.53	14.52
Cameroon	0.0011	0.64	24.64	99.12	0.52	<b>11.73</b>	26.71	12.76	614.38	3.79	21.48	3.52	11.61
Cape Verde	0.5790	0.6	<b>23</b>	<b>99.94</b>	0	64.1	<b>76.4</b>	<b>66.1</b>	1396.7	1.76	59.55	0.18	36.66
Congo Rep	0.0449	0	76	<b>99.86</b>	0	12.39	19.74	<b>9.51</b>	1134.5	7.17	8.64	0.5	7.64
Cote d'Ivoire	0.0128	0.64	<b>97.36</b>	98.77	0.36	24.38	13.35	12.31	600.14	5	20.78	2.99	18.5
Egypt	0.0105	0.56	37.5	<b>80.48</b>	<b>0.64</b>	38.56	24.09	49.32	1564.3	9.65	41.13	81.08	38.71
Ethiopia	0.0004	<b>0.68</b>	<b>24</b>	99.01	0.24	29.31	<i>11.68</i>	27.08	<b>156.31</b>	10.01	26.25	2.55	13.35
Gabon	0.1404	0.16	72	99.62	0.56	26.74	54.27	37.8	<b>4333.9</b>	6.38	28.23	1.2	10.37
Ghana	0.0206	<b>0.68</b>	<b>83.2</b>	98.4	0.36	54.12	42.19	50.31	295.98	21.32	52.94	6.12	11.13
Kenya	0.0154	0.32	76	98.75	<b>0.64</b>	15.8	13.89	19.16	437.17	11.26	35.36	4.22	24.96
Madagascar	0.0003	0.6	36	99.68	0.24	49.46	38.83	34.95	245.45	12.9	26.94	0.93	11.39
Mali	0.0108	0.56	64	99.79	0.44	34.19	43.73	39.72	<b>232.16</b>	3.47	20.94	0.62	14.43
Mauritius	0.0479	0.36	68	99.3	<b>0</b>	<b>70.99</b>	<b>76.86</b>	<b>79.86</b>	<b>4064.8</b>	5.59	72.77	1.63	65.72
Morocco	0.1887	0.68	53.52	95.15	<b>0.64</b>	52.52	34.18	52.64	1506.8	1.91	52.49	16.68	43.86
Mozambique	0.0337	0.4	52	97.63	<b>0</b>	37.69	49.18	29.63	287.09	18.75	37.69	5.79	14.37
Namibia	0.0010	0.56	76	99.63	0.64	66.13	65.44	58.39	2280.2	8.32	61.03	2.27	42.26
Nigeria	0.0058	0.36	68.4	94.08	0.36	<b>9.78</b>	<b>7.65</b>	10.83	436.84	21.6	14.08	13.79	14.91
Rwanda	0.0183	0.36	38	<b>99.95</b>	0.36	47.39	21.54	26.63	272.84	10.08	35.44	0.25	9.96
Senegal	0.0112	0.64	56.16	99.59	0.64	48.58	33.29	48.22	509.06	3.28	46.82	1.47	22.32
South Africa	0.0632	0.36	70.72	<b>58.87</b>	0.44	<b>66.64</b>	39.4	55.94	3307.9	8.84	71.35	186.12	64.74
Tanzania	0.0087	0.24	72	99.25	0.48	26.98	32.61	41.28	353.21	15.6	35.6	2.49	9.04
Tunisia	0.0296	0.4	<b>88</b>	97.24	<b>0</b>	57.61	44.31	52.27	2429.9	4.61	65.69	9.42	57.09
Uganda	0.0194	0.6	47.44	99.63	0.52	20.52	13.56	36.93	289.75	12.19	36.85	1.53	8.22
Zambia	0.0344	0.68	69.6	98.27	0.52	29.21	50.85	36.99	292.5	37.04	22.98	7.36	7.97
Zimbabwe	0.0203	0.44	34.68	97.96	0.48	11.79	16.63	<b>7.88</b>	446.52	3.01	18.46	8.9	39.57

\*\* The top three countries in each variables are highlighted in **bold**, While the three lowest are in *italics*.

The dependent variable derived from Net total private investment divided by the total population of each country.

## 6.8 Estimation and Empirical Results

The regression model used is to gauge our hypotheses to empirically test the impact of market-oriented reforms, institutional and government commitment indicators and macroeconomic stability variables on the public-private investment in the electricity supply industry, using aggregated cross-sectional data for a sample of 28 countries in Africa during 1990 – 2014. A number of adjustments were made to correct for heteroscedasticity, we used log of private sector investment in electricity supply industry minus by the population as a dependent variable to avoid heteroscedasticity. This approach also provides a robustness check to validate our findings when the economic giant of the region is excluded.

### 6.8.1 Empirical Results

In this section, we employed the orthodox (stepwise) estimation to test our hypotheses on the factors influences the private sector investment. Starting (with individual variables estimation, before moving to more complex one).

$$\ln netinvcap_i = f(\text{regul}, \text{Privtz}, \text{compt}, \text{unbund}) + (\text{corrpt}, \text{judindp}, \text{polst}, \text{Rulaw}) + (\text{infatn}, \text{Asscap}, \text{Lnr GDPcap}, \text{Lnenecons}) + \varepsilon_t \quad (6.2)$$

Where:

- Regul = Regulation
- Privtz = Privatisation
- Compt = Competition
- Unbund = Unbundling
- Corrpt = Corruption
- Judindp = Judiciary Independence
- Polst = Political Stability
- Rulaw = Rule of Law
- Infatn = Inflation
- Asscap = Access to capital
- Lnr GDPcap = log of real GDP per capita
- Lnenecons = log of energy consumption

The estimates results are reported in table 6.8. The parameters on natural logarithms are interpreted as elasticities. The political institution/government effectiveness model as presented in column 1 explains the percentage variation in PPPI in the region. The second and third columns report the market-oriented reform and macroeconomic stability and control variables. Then four columns deals with unified models percentage variation with the incorporation of interaction effect mode. We produced estimations showing the relationships between the log of net private-public investment per capita in power sector with its key determinants, market-oriented reform variables and control variables. Our empirical results are classified into two set of relationship:

**Table 6.8: Estimation Results of Factors Determining Private Sector Investment in Africa**

Explanatory variables		Institution and government commitment	Market-oriented reform	Macroeconomic stability and Control Variables	Unified Models
Variables Name	Parameters	Eq.1	Eq.2	Eq.3	Eq.4
Corrpt	$x_1$	-0.040 (0.032)	-----	-----	-0.010 (0.039)
Judindp	$x_2$	-0.011 (0.011)	-----	-----	-0.023 (0.034)
Polst	$x_3$	0.012 (0.023)	-----	-----	0.012 (0.027)
Rulaw	$x_4$	0.049 (0.033)	-----	-----	0.052 (0.037)
Regul	$x_5$	-----	-0.256 (0.525)	-----	-2883.222 (2.301)
Privtz	$x_6$	-----	-0.009 (0.008)	-----	0.158** (0.082)
Compt	$x_7$	-----	-0.024 (0.119)	-----	0.210 (0.162)
Unbund	$x_8$	-----	-0.119 (0.498)	-----	(Omitted) <sup>117</sup>
Infatn	$x_9$	-----	-----	-0.021 (0.019)	-0.029 (0.019)
Asscap	$x_{10}$	-----	-----	-0.024 (0.002)	-0.003 (0.028)
lnrgdpcap	$lnx_{11}$	-----	-----	3.161** (1.558)	2.158 (1.667)
lnenecons	$lnx_{12}$	-----	-----	-2.024*** (0.737)	-1.494 (0.962)
Interaction effect models <sup>118</sup>					
Regvtz	$z_1$	-----	-----	-----	29.141 (55.993)
Regmpt	$z_2$	-----	-----	-----	29.039 (56.255)
Regund	$z_3$	-----	-----	-----	2894.117 (5575.946)
Primpt	$z_4$	-----	-----	-----	-0.002** (0.0009)
Priund	$z_5$	-----	-----	-----	-0.067* (0.038)
Comund	$z_6$	-----	-----	-----	-29.167 (56.245)
Reprmt	$z_7$	-----	-----	-----	-0.294 (0.565)
Reprnd	$z_8$	-----	-----	-----	-29.175 (55.986)
Prmund	$z_9$	-----	-----	-----	0.292 (0.562)
Recound	$z_{10}$	-----	-----	-----	(Omitted) <sup>119</sup>
Repround	$z_{11}$	-----	-----	-----	0.003 (0.007)
R-squared		0.37	0.27	0.092	0.31
constant		-3.468*** (0.566)	0.0467 (11.402)	-19.649** (9.199)	-33.237* (18.790)
Preferred Model		Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Number of groups		28	28	28	28
Number of observation		126	126	126	700

**Note:** The dependent variable is the log of real private sector investment per capita (*lnnetinvestcap*). Standard error are in parentheses

\*, \*\*, \*\*\* indicate significance of the coefficient respectively at 10%, 5% and 1% confidence level.

<sup>117</sup> STATA drop Unbund due to collinearity.

<sup>118</sup> Interactions effect model is the interplay among explanatory variables that produces an effects on the outcome dependent variable (*lnnetinvpul*) which is the different from the sum of effects of the individual predictors. If two explanatory variables interact in determining a response variable when the partial effect of one depends on the value of the others (see appendix for detail)

<sup>119</sup> The interaction of regulation, competition and unbundling was dropped due to collinearity.



First, the individual institutional, liberalisation reform and macroeconomic stability variable's impact on PPP-investment in the power sector. Second, reflects the interaction effect on the PPP-investment performance as result of combination effect of the market-oriented reform in the electricity market. We carried out some model diagnosis tests in order to strengthen our results. We conducted Hausman test in order to choose the preferred model, and Wooldridge test for autocorrelation in panel data. Also, the adjusted R-squared (in table 6.8) show the model explained 31 variations the key determinant of PPP-investment in power sector in the region. Thus, these shows there are other factors that prevent the flow of PPP-investment in power sector in Africa region. Nevertheless, the rise in economic growth in the region for the last decade has not influenced the full private sector participation in the power sector reform. Some of these factors are as a result of low or non-existent of sovereign credit ratings among these countries and the absence of proper financial instruments to handle the risks associated with power projects and among other factors inherent in electricity market.

### ***6.8.1 Political Institution/government commitment***

In column 1, our objective is to establish the proportion of the variation in the private sector investment per capita that can be explained collectively by the political institution/government commitment. Our results show that the institutional variables could only explained 37% variation in the private sector investment in the sector. Thus, none of the variables were statistical significant, although the political stability and rule of law variables were positive. Therefore, African economies with stable judicial system (i.e. independence from elites and political pressures, adherence to rule law and political stability all maintained the appropriate signs, but statistically insignificant) which shown that political institution matters, but it is not the sole factors that influences private investors decision. Furthermore, our findings shows that most corrupt countries in the region attracted less PPP-investment, which is if one-unit increase in corruption leads to 4.0% less in PPP-investment. This result corresponds to Emirullah & Azam (2006) on the study of public-private partnership in ASEAN countries in provision of infrastructure<sup>120</sup> in emerging markets.

### ***6.8.2 Market-oriented reform***

Our result in column 2 showed the variation of all the market-oriented variables are statistically insignificant, but with appropriate sign. Turing to the effects of the market-

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<sup>120</sup> PPI database classifies infrastructure into four sectors – Electricity, Telecommunication, Transportation and Water.

oriented reform shown that establishing regulation, privatising inefficient state-owned enterprise, introducing competition and separating the segment of the industry individually is necessary conditions, but not sufficient to influence the outcome of the private sector investment in the sector.

### ***6.8.3 Macroeconomics stability and control variables***

Intuitively, the parameters in column 3 shown only the real GDP per capita was positive and statistically significant at 5%. (i.e. countries with higher real GDP per capita are more designated to attract more private sector investment as they are have higher purchasing power and greater projected demand in the power sector. This result was consistent in all our specifications. Therefore, for every dollar increase in real GDP per capita promotes higher private sector investment in the power sector by 99%. This could confirm that real GDP per capita is a good indicator, as the private sector invests in countries with the affordability to pay for its services.

### ***6.8.4 The Interaction Effect Models***

We experimented with different model by the including the interaction effect as reported in table 6.8. Our result is reported in (column 4). Based on our model selection this is refers to as the preferred model. The result shown individual market-oriented variables are statistically significant, some with expected signs. However, there is evidence of crowding-out of private sector investment in power sector. Our result suggests that countries with deepen market-oriented reform attract lower private investment flows. For instance, higher percentage of countries in the region that have adopted at least two reform variables experiences reduction in total net private sector investment by 6% and 29% respectively. In addition, with rise in establishing regulatory bodies, privatizing new projects, introducing competition and separating the three segment of the sector leads to increase in private sector investment in the sector by 3% holding other factor constant (i.e. government commitment in electricity market reform matters in attracting PPP-investment, thus corresponding to our chapter four results).

## **6.9. Robustness Check**

We explore the classification of each of the countries, as we are aware of, that all these countries are not equal. To avoid these problems, see table 6.9, we provide empirical result

without South Africa. Our hypothesis is that if the coefficients do not change significantly, then we take it to be evidence that these coefficients are “robust”<sup>121</sup>(Lu and White, 2014).

The detailed results, as presented in Table 6.9 shown no significant variation in the interaction effect and the real GDP per capita is significant just like in the preferred model. From the result, it is evidence that South Africa is an economic giant of the region, and absent of the country in the sample not affected the private sector investment in electricity market in the region. It shown that the true determinant of private sector in power sector in the region is the wealth of the people.

In order to gain depth insight of the relative effect of different factors influencing the private sector investment in Africa, we estimated the interaction effect excluding South Africa. Thus dropping South Africa from the model, does not change anything. Therefore, South Africa do not constitute outlier in the model.

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<sup>121</sup> The word “robust” in this content should be confused with the concept of robustness in the statistics literature, which refers to the insensitivity to covariate selection, typically extreme in some way. What we refer to here is the degree of insensitivity of an estimator to adding or removing sample observation.

**Table 6.9:** The estimation outcome without South Africa of the factors determining private sector investment in Africa

Explanatory variables		Institution and government commitment	Market-oriented reform	Macroeconomic stability and Control Variables	Unified Models
Variables Name	Parameters	Eq.1	Eq.2	Eq.3	Eq.4
Corrpt	$x_1$	-0.012 (0.031)	-----	-----	-0.039 (0.035)
Judindp	$x_2$	-0.036 (0.026)	-----	-----	-0.044 (0.029)
Polst	$x_3$	-0.019 (0.021)	-----	-----	-0.019 (0.026)
Rulaw	$x_4$	0.001 (0.031)	-----	-----	0.017 (0.034)
Regul	$x_5$	-----	-0.831 (0.457)	-----	-435.346 (474.863)
Privtz	$x_6$	-----	-0.010 (0.064)	-----	0.376 (0.271)
Compt	$x_7$	-----	-0.149 (0.112)	-----	0.856** (0.368)
Unbund	$x_8$	-----	0.264 (0.434)	-----	(Omitted) <sup>122</sup>
Infatn	$x_9$	-----	-----	-0.023 (0.016)	-0.029* (0.017)
Asscap	$x_{10}$	-----	-----	-0.013 (0.020)	0.024 (0.028)
lnrgdpcap	$lnx_{11}$	-----	-----	2.089 (1.349)	1.937 (1.499)
lnenecons	$lnx_{12}$	-----	-----	-1.837*** (0.630)	-0.863 (0.840)
Interaction effect models <sup>123</sup>					
Regvtz	$z_1$	-----	-----	-----	44.029 (47.563)
Regmpt	$z_2$	-----	-----	-----	43.847 (47.783)
Regund	$z_3$	-----	-----	-----	4380.83 (474.998)
Primpt	$z_4$	-----	-----	-----	-0.003 (0.003)
Priund	$z_5$	-----	-----	-----	-0.153 (0.247)
Comund	$z_6$	-----	-----	-----	-44.170 (47.783)
Reprmt	$z_7$	-----	-----	-----	-0.444 (0.479)
Reprnd	$z_8$	-----	-----	-----	-44.166 (47.557)
Prmund	$z_9$	-----	-----	-----	0.443 (0.478)
Recound	$z_{10}$	-----	-----	-----	(Omitted) <sup>124</sup>
Reprund	$z_{11}$	-----	-----	-----	0.004 (0.007)
R-squared		0.045	0.138	0.120	0.35
constant		-2.197*** (0.561)	-16.291 (11.142)	-13.352** (7.954)	-95.859*** (36.006)
Preferred Model		Fixed Effects	Fixed Effects	Fixed Effects	Fixed Effects
Number of groups		27	27	27	27
Number of observation		116	116	116	675

<sup>122</sup> STATA drop Unbund due to collinearity.

<sup>123</sup> Interactions effect model is the interplay among explanatory variables that produces an effect on the outcome dependent variable (lnnetinvpul) which is the different from the sum of effects of the individual predictors. If two explanatory variables interact in determining a response variable when the partial effect of one depends on the value of the others (see appendix for detail)

<sup>124</sup> The interaction of regulation, competition and unbundling was dropped due to collinearity.

## 6.10 Discussion and Conclusion

The primary purpose of this study is to establish the factors influencing of private sector investment in power sector in Africa. As the countries across the region faced similar situation, but attract different outcomes in terms of volume of private investment inflow.

Our result suggests that political institution matters, but not to our expectation especially when compare to the literatures. In principle, countries with low corruption rate, strong political institutions and haven adopted market-oriented reform are to enjoy significant increase inflow of private sector investment than other countries. Also, countries with a low inflation, flexible access to capital, high real GDP per capita and used more energy suggest to attract more of the private investment. This result is corresponded to earlier findings by number of studies such as (Habib and Zurawicki, 2002; and Mauro, 1995). Thus, our model only explained 31% variation of the key determinant of PPP-investment in the power sector, which shows low variation. However, due to lack of availability of data on sovereign credit rating, country risk and absence on financial instruments to mitigate the risk involved in power sector projects contributed to the low variation. Our results shows that both foreign and domestic private investors favours to invest in countries with relative high income per capita, as there tend to focus more on returns to investment.

Second, we may investigate if countries with abundant natural resources endowments in the region attract more private investment to justify such behaviours from private sectors.

However, to improve this study we suggest using lagged dependent<sup>125</sup> variables in dynamic panel data estimation. As the circumstance between fixed effects and random effects formulation has the implications for estimations that are of a different nature than those associated with static model. Lastly, this chapter has set the objective of empirically investigating the determinant of PPP-investment in Africa region electricity market.

We believe that our study contributed to existing literature, especially with regard to developing countries, in particular Africa region.

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<sup>125</sup> Thus if lagged dependent variables also appear as independent variables, then the strict exogeneity of the regressors no longer holds.

## Chapter 7

### Conclusion and policy recommendations for further research

#### 7.1 Conclusion

In this study, we have made a conscious effort to assess and analyse the performance of the electricity market in the African region. Our objective is to develop an economic perspective on electricity market reform, with a specific emphasis on understanding the impact of market-oriented reform (i.e. *regulation, privatisation, competition and unbundling*) on the performance of the power generation sector, to identify factors that promote efficiency in power distribution, and to examine factors influencing private sector investment in the electricity market. The backdrop of market-oriented reform has been adopted by many developing countries with the expectation for that the benefits will be visible to the customers (end users). This thesis contributes to existing literatures in analysing electricity market reforms in the African region with through an econometric approach based on cross-country analysis.

The approach employed in this research to analyse the electricity market reform in developing economies by drawing upon three main methods used in analysing electricity reform as identified by Jamasb et al (2004): *an econometric approach, efficiency and productivity analysis methods, and comparative case studies*. The first method (the econometric approach) is best suited to an analysis and testing of hypotheses on electricity reform and performance in the power generation sector. The second approach (the efficiency and productivity method) is best used when measuring the effectiveness with which inputs are transformed into outputs, relative to best practice. The third method is for a single-country or cross-country study. Of these three methods, our study draws upon the first, second and an element of the third category.

This chapter is arranged into five sections. First, we discuss whether we have answered the questions that gave rise to this research as stated in chapter one. The second connects to the policy consequence of results - either to a country that consider embarking on reform or to policy makers for such a country. The third section deals with the policy recommendations of our result, fourth section highlights the limitation of our research and lastly, what area(s) for further study are discussed in the final section.

## 7.2 Have the research questions been answered?

This research were motivated by basically three main questions. The first question and objective seek to answer to what extent do market-oriented reform impact on the performance of a specific segment of the industry (power generation). Our research found that while there are few significant impacts of the reform variables on power generation performance when considered alone, they tend to be more effective when they co-exist or interact with other reform variables. So for countries to obtain first-best outcomes in electricity market reform, it is important to introduce more than one reform at a time in the reform process. Power sector reform in African countries are characterized with amended of electricity law to attract independent power producers (IPPs), corporatization of service provision, and the creation of new institutions such as regulatory authority to support reform activities. While there is no strong commitment to fully embark on privatisation, retail competition and unbundling, as the government prefers to engage in private sector participation and public-private partnership in power generation. This system promotes hybrid structure where the state-owned vertically integrated power companies still dominated as act as a single buyer.

The second question and objective in the second empirical paper employed a stochastic input distance function using multiple inputs and outputs (which have been adjusted to account for the influence of exogenous factors such as *peak load* and *customer density* ) to evaluate the performance of the electricity distribution companies in the region. Moreover, we observe the behaviour of electricity distribution companies ‘when the number of outages/disruptions (a proxy for the quality of service) enters in the company’s production function as an undesirable input variable (i.e. an imperfect substitute for unscheduled maintenance activities, and planned interruptions)’. Our findings show an improvement in technical efficiency of EDISCOs when the quality of service is incorporated into the model. Thus, this allows us to identify the sources of technical inefficiency and the underlying trade-off faced by EDISCOs between the cost of improving the quality of service and other inputs.

Lastly, the third question and objective examined what causes disparity in attracting private sector investment in the power sector of 28 African countries. Contrary to conventional expectation, results generated by our model imply that private investors do not place too much emphasis on the level of corruption perception of a country in their investment decision. Political stability, rule of law and judiciary independence are unlikely to influence private sector investors although there maintain appropriate signs. In fact, adopting market-

oriented reform (i.e. regulation, privatisation, competition and unbundling) alone into power sector is necessary condition, but not a sufficient condition in terms of increasing the private sector investment, only when co-exist that the reform variables makes impacts. Our finding indicates that private investment is influenced by the high real GDP per capita of a country (i.e. countries with high marginal utility to income and wealth will attract more private investment in its power sector as there have the income to afford the services provided by the private sector).

### 7.3 Policy consequences of our results

In this section, we mention the policy consequences of our results, knowing fully well that the validity of our result may have been limited by some factors (as specified in 6.5). Our results have five policy implications.

Power sector reforms in Africa have taken place within diverse political, economic, and structural contexts. Many of the reforms were initiated as a result of conditions to secure loans, aid, responds to economic crisis, and as part of a structural adjustment programme (SAP). Consequently, power sector reforms have taken a variety of forms and paths. It is perhaps not surprising that many African countries have encountered unexpected problems and some have only achieved to some extent limited results.

Our findings in chapter four indicate that for improvement in terms of increase in total electricity generation, installed capacity and capacity utilisation, it suggests that a country should adopt at least three market-oriented reforms in the power sector. This implies a uniform pattern for all the countries. That is to say that similar reforms adopt by different countries work in the same way for different countries in the region. Thus, this is our *first* policy implication (i.e. reform prescription for a particular country may not work the same for another). Therefore, why is vital to initiate a reform or embark on the progress, it is essential to widen the reform agenda to include local conditions.

The second empirical chapter tried to explain effect of exogenous factors (*such as customer density and peak load*) on the electricity distribution companies' efficiency level; how do electricity distribution companies behave when the quality of service is incorporated to its production function. Based on the result obtained from the chapter, we form our second and third policy implications. The *second* policy implication of our results is that the amount of energy delivered to customers and the number of transformer has a significant influence on the technical efficiency level of electricity Distribution Company. Therefore, while designing



a power sector reform, it is important to plan the distance between distribution transformers, in order to avoid unnecessary power outages.

The *third* policy implication implies that the electricity distribution companies always meet their quality of service targets as set by the regulatory body. Our result shown that incorporating the quality of service to the production function allows us to identify the sources of technical inefficiency and underlying trade-off faced by EDISCOs. That is to say that electricity distribution companies perform better under an incentive regulatory system.

Our last empirical chapter examined factors that influencing the private sector investment in power sector using political institution/ government commitment indicators, market-oriented reforms and macroeconomic stability variables. In other words, strong political institution structure (such as a *strong judicial system, a low corruption rate, political stability and adherence to the rule of law*) promote increase in private sector investment; also, market-oriented reform matters in attracting private sector investment in electricity market in the region and lastly macroeconomic stability (*i.e. low inflation, access to capital*) stimulates increase in private sector investment in African electricity market. Based on the results from this chapter, we form the fourth *and* fifth policy implications.

The *fourth* policy implication suggest countries with *low corruption perception, freedom from political instability, independent of judiciary and rule of law attract more private sector investment*. Our result revealed only corruption is significant. The *fifth* policy implication deals with the fact that market-oriented reform and strong macroeconomic stability variables influence private investment positively. Our findings indicate that these variables matter, but not sufficient to increase private sector investment.

#### 7.4 Policy recommendation

In sum, discussion over the effects and impact of market-oriented reform on electricity market is heated, ongoing, and oftentimes uninformed, as some people believed that it has led to an increase in access, and improved quality of services, while on the other side, market-oriented reform is criticised as a failure and an attempt for a few individuals to control a country's essential service. It is no easy task to arrive at a definite ground of reforms—let alone offer a general acceptable policy recommendation. All of these issues cannot be addressed here; rather, our main purpose in this section is to shed light on the way forward for developing economies, especially the African region, while recognizing the inherent

limitations of these sources. Our policy recommendations to a country that wants to implement or redesign its reform programme in their power sector is to:

(i). Bear in mind that not all market-oriented reforms in electricity market are successful (i.e. *there are no one-size-fits-all reforms*), also it is clear to state that electricity market reform is an evolving and changing process rather than a one-off event. Therefore, in the context of an environment characterized by unsustainable macroeconomic policies, inadequate political institutions and government commitments, the reform may fail. African countries should therefore avoid the pitfall of many developing countries by imitating developed countries structure and design in their power sector reform. It is critical to pay attention to local conditions. Reforms that are imported from outside and imposed on the people without considering local status may not be successful; rather it may weaken institutions that generate mechanisms of social identification and social protection. For instance, consider the composites of the country first and its history, as what works for Nigeria may unlike work for Egypt.

(ii). Market-oriented reforms in electricity market are not the end but a means. There are necessary, but not sufficient conditions for improving and achieving the first-best in power sector reform. Therefore, strong political institutions, government commitment and conducive environment are vital, also the right people to manage the sector are important in power sector reform success (*see chapter six discussion*).

(iii). Electricity tariff reform should come first before overall power sector reform of the industry. The problem of cost recovery, under-pricing and subsidy pose serious challenges to the success of electricity market reform (Kessides, 2012b). Low cost recovery and subsidies in the market limit private sector participation, as it lacks the incentive for private investors to make profit from their investment. Therefore, it is important for countries to first and foremost restructure its tariff structure and remove subsidy incentive from the system, before embarking on electricity market reform. As in many African countries, energy subsidies exist side by side with high power tariffs, making it difficult for full private sector participation and in such circumstance, it is difficult for the power utilities to recover cost. For instance, the Nigeria electricity market reform shows that power sector reform without first restructuring its electric tariff affect its success. In December, 2013, the country had achieved most of the power sector reform milestone, without fully restructure the tariff structure (Kojima et al.2014).

(iv) However, it is important that after reforming the tariff structure and cross-subsidies removes or reduced, that periodic review be implemented to confirm with the best practise in the sector. As one of the recent example, the Uganda electricity regulatory agency introduced tariff quarterly adjustment methodology in January, 2014. This review responds to changes in power generation mix, exchange rate, and inflations (ERA, 2014).

(v). lastly, power sector in Africa countries should not just be discrete parts (i.e. there should be introduce retail competition in the supply segment to give customers options to choose from. Also, rural supply should be incorporated into the reforms, just as the urban supply, because private sector prefers to involve in cities and urban areas power supply than rural areas, because of return on investment(ROI) are higher in the former than later. Retail competition in the electricity market gives the consumers the opportunity to choose their own supplier as the case in Norway, Great Britain and European Union countries. It is the mainstream of the power sector reform in developed countries.

### 7.5 Limitation of the research

In the course of this doctoral research, I have experienced frustration caused by wrong estimation, anticipated correct sign for a favourite variable turn to be the opposite. The disappointment one encounters when faced with an *assumed straightforward estimation* of a preferred model that turned out to be a wrong estimation could affect quality of a research.

Due to the nature of our study, coupled with limited dataset tend to give rise to some potential limitations;

Just like any other econometric analysis on market-oriented reform, the problem of endogeneity may occur in our analysis (i.e. when an explanatory variable is said to be correlated with the error term) these could be a result of measurement error or a loop of causality between the explanatory and explained variables. In other word, some independent variables in our model may have influence the dependent variable. One solution to this problem is to select good instrumental variables (IV)<sup>126</sup>. Thus, it was difficult to find a good instrumental variable, so we did not consider adopting this technique in our analysis, rather we used panel data which involved fixed effect. Therefore, by using country fixed effect we control the problem of endogeneity in our analysis.

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<sup>126</sup> There are two basic requirements for a good instrument; (i). Have to be correlated with the endogenous explanatory variables, based on the other covariates. (ii). the instrument must not be correlated with the explanatory variables. If these conditions are not met, then using instrumental variables is not valid.

Another source of shortcoming to our analysis is due to limited datasets. In our first, second and third empirical chapters, our samples size were 30, 16 and 28 countries respectively. Suppose in our regression estimation, as measured the impact of market-oriented reform on the performance of power generation performance in African countries. Our data have different results for different dependent variables than those without data availability. The consequence of this will be selection bias and misleading results. Therefore, in our analysis, we select only countries that have adopted reform and the period of observation are all the same across the dataset.

Lastly, another problem common which is often ignored is the problem of outliers. In our estimation of factors that influences private sector investment in power sector. We adopted an aggregated data, our results shown the real GDP per capita was positive, and statistically significant. For clear understanding, we dropped South Africa in the sample, and regressed again (robustness check). In the second estimation, real GDP per capita was insignificant and negative, which signifies that South Africa was an outlier in the model.

## **7.6 Some recommendations for further research**

This research has analysed the economics of electricity market reform focusing on African region. This analysis has provided in-depth understandings about the reason African countries are where there are in term of achieving reliable and efficient power supply.

The approach employed by this research is to examine the extent of market-oriented reform impacts on the power generation performance, power distribution companies' technical efficiency and the private sector investment in the sector. It is basically an econometric approach used, therefore, we could use case study approach with data envelopment analysis to analyse the efficiency and productivity of each of the country's power generation and distribution firms' performance in post and pre- reform and in measuring technical efficiency of each country distribution firm(s). As this will explore more hidden information.

Besides, the approach could include using other relevant data, which was not available for all the countries in the sample at the time of writing to improve on the result.

More economic analysis on factors influencing private sector investment in power sector is critical to evaluate the effect of natural resources endowments of a country on private sector investment. In addition, comparison study on electricity trading in the developed and developing regions might explain other factors that could influence private sector investment.

Based on our analysis, it appears that countries with high real GDP are able to attract more private sector investment.

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