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ELECTRICITY SECURITY OF SUPPLY
IN GHANA

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POWER MARKET REGULATORY STRUCTURES AND ELECTRICITY SECURITY OF SUPPLY IN GHANA

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ABSTRACT

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Power Market Regulatory Structures and Security of Electricity Supply in Ghana

Keywords: Gas aggregator; Independent Power Projects (IPPs); New Institutional Economics; power project bankability; regulation; state ownership; legal rearrangements.

This research examines the impact of certain energy sector-specific variables on electricity security of supply in Ghana, in the context of the existing power markets and regulatory structures. The thesis examines this issue along three main themes.

The first part of this study examines whether the gas resources available to Ghana should be used largely for power production or for the other alternative uses. The analysis shows that with the current trends in carbonisation and using gas resources to support electricity security of supply is the best option.

The second part of the study examines the impact of some power market-specific variables on electricity security of supply. Using the panel data approach, the results show that while plant installed capacity or size and sustainability characteristics of power plants, impact significantly on the measure of electricity security of supply in Ghana, there is no significant impact of financial efficiency, regulation and ownership.

These findings suggest that the new institutional economics of changing the power generation mix should be critically evaluated and monitored as Ghana

being a resource- rich but capacity short country transits through the energy ladder.

The third part of the study examines how Ghana can eliminate its capacity shortness through documentation analysis and the use of comparative legal methodology. The analysis shows that the proper sequencing of institutional designs and their implementation will determine the success of the measures to be taken by policy makers.

The policy implications of these findings suggest that the Ghanaian power sector reforms should be grounded on an effective legal and regulatory framework and implementable mechanisms. These mechanisms should be complemented with an adequate fiscal space and financial structures in a well sequenced manner in order to manage the expectations of the constituent IPPs, other investors and consumers. These measures are needed to guarantee the sustainability of the electricity sector and prevent energy injustice against the unborn generation.

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STATEMENT OF ORIGINALITY

I hereby state that I am the Author of this thesis. Unless otherwise indicated, I declare that, I have consulted all references cited, and that I have performed the work for which this thesis is the result.

Francis M. Sasraku

August 2018

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

ANOVA	Analysis of Variance
AIT	Average Interruption Time
BITs	Bilateral Investment Treaties
BOT	Build Operate and Transfer
BOOT	Build Own Operate and Transfer
BOST	Bulk Oil Storage and Transport Company of Ghana
CAIDI	Cummulative Average Interruption Duration Index
CEER	Council of European Energy Regulators
CCGT	Combined Cycle Gas Turbines
CEPA	Cambridge Energy Policy Associates
DEA	Data Envelopment Analysis
ECG	Electricity Company of Ghana
ECT	Energy Charter Treaty
EIB	European Investment Bank
ENTSO-E	European Network of Transmission System Operators for Electricity
EPA	Environmental Protection Agency of Ghana
EPEC	European Public –Private Partnership Expertise Centre
EPFI	Equator Principle Financial Institution
ESLA	Energy Sector Levy Act
ESMAP	Energy Sector Management Assistance Programme
ESoS	Electricity Security of Supply
EU	European Union
FE	Fixed Effects Model
FERC	Federal Energy Regulatory Commission
GDP	Gross Domestic Product
GHGs	Green House Gases
GIPC	Ghana Investment Promotion Centre
GLS	Generalised Least Squares
GMM	Generalised Method of Moments
GoG	Government of Ghana
HAC	Heteroskedasticity and Autocorrelation
HFO	Heavy Fuel Oil
HIPC	Highly Indebted Poor Countries
IAS	International Accounting Standard
IBTs	Increasing Block Tariffs
ICSID	International Centre for Settlement of International Disputes
IDA	International Development Association
IEA	International Energy Agency
IED	Industrial Emission Directive
IFC	International Finance Corporation
IFRS	International Financial Reporting Standard
IITs	International Investment Treaties

IMF	International Monetary Fund
IPPs	Independent Power Projects/ Producers
ISOs	Independent System Operators
ISO-NE	Independent System Operator –Northeast USA
LACE	Levelised Avoided Cost of Electricity
LCOE	Levelised Cost of Electricity
LCs	Letters of Credit
LCPD	Large Combustion Plant Directive
LFGTE	Landfill Gas to Energy
LNG	Liquified Natural Gas
LOLE	Loss of Load Expectations
MIGA	Multilateral Investment Guarantee Agency
MITs	Multilateral Investment Treaties
MoF	Ministry of Finance
MOU	Memorandum of Understanding
NAFTA	North American Free Trade Agreement
NEDCO	Northern Electricity Distribution Company of Ghana
NERC	North American Electrical Reliability Council
NIE	New Institutional Economics
NPAM	Network Performance Assessment Model
NY-ISO	New York Independent System Operator
OCGT	Open –cycle gas turbine
OCTP	Offshore Cape Three Points
ODA	Overseas Development Agency
OECD	Organisation for Economic Co-operation and Development
OFGEM	Office of Gas and Electricity Markets
OLS	Ordinary Least Squares
PDS	Power Distribution Service Ghana Limited
PJM	Pensylvania, Jersey and Maryland Interconnection LLC
PPR	Power Project Sanayi
PURC	Public Utilities Regulatory Commission of Ghana
PV	Photovoltaic for solar energy
RAED	Renewable and Alternative Energy Directorate
RE	Random Effects Model
RISE	Regulatory Indicators for Sustainable Energy
SADC	South African Development Corporation
SAIDI	System Average Interruption Duration Index
SAIFI	System Average Interruption Frequency Index
SAPP	South African Power Pool
SB	State –Owned Banks
SBLC	Standby Letters of Credit
SEC	Ghana Securities and Exchange Commission of Ghana
SFA	Stochastic Frontier Analysis
SG	Sovereign Guarantee
SHV	Shareholder Value

SMEs	Small-and Medium-Sized Enterprises
SoES	Security of Electricity Supply
SSA	Sub –Saharan Africa
SSNIT	Social Security and National Insurance Trust
STV	Stakeholder Value
TCE	Transaction Cost Economics
UNCTAD	United Nations Conference on Trade and Development
UNGA	United Nations General Assembly
UNIDO	United Nations Industrial Development Organisation
VOLL	Value of Lost Load
VRA	Volta River Authority
WAGP	West African Gas Pipeline Company

CHAPTER 1

INTRODUCTION

1.1 BACKGROUND OF THE THESIS

The level of a country's power generation is central to the development of its power market. The availability of power is also a key indicator of the level of energy security that a country experiences (Best and Burke 2018). Electricity security is measured from its affordability, availability, accessibility and acceptability (Cherp and Jewell 2014). Electricity security also reflects the degree of a country's economic development. Practically, the availability of electricity is determined by the level of demand, availability of fuel input, adequate production capacity and sustainable investment climate for independent power projects (IPPs) in many developed(Heffron and Talus 2016a) and developing countries (Eberhard et al 2016).

A country's ability to generate electricity to meet its base load demand determines whether it is capacity surplus or capacity short. A capacity short country therefore does not produce electricity enough to meet its base load. Countries that are capacity short tend to pay heavy prices in varying forms from short term energy crisis situation that they face to energy poverty which manifests itself in a condition where large swatches of the population have inadequate access to energy supplies. Such situations are characterised by insufficient and unreliable access to electricity that deprive the population the ability to service basic household needs. Electricity is the bedrock of every modern society's development as it is an integral part of the day –to –day activities. Therefore its availability forms part of the current energy law core principles which require that countries minimise energy poverty and increase accessibility for societal balance (Heffron and Talus 2016 b).

Ghana's recent energy crisis can be best described as energy poverty in the mist of plenty or 'paradox of plenty'. Studies have shown that there is a fairly strong correlation between electricity use and its intensity and the level of economic development (Osman et al 2016) and wealth creation (Cameron and Stanley 2017). It is therefore not surprising that many countries that are capacity short are generally third world countries or developing countries. The analysis of capacity shortness in the electricity markets involves the evaluation of the balance between demand and supply. This also requires an in-depth analysis of the necessary investments needed to achieve this balance. This has become necessary to understand the complex nature of activities and their associated costs and prices of generating electricity (Eberhard et al 2016).

Electricity can be generated from many sources including renewable sources such as hydro, thermal sources from fossil fuel such as oil and gas, alternative sources such as the use of biomass like wood, sugarcane among others. The focus of this research is to analyse the power generation mix in Ghana and ascertain if it is being developed and integrated with the resource endowment of the country. It looks particularly at resource abundance in the form of gas, water, solar and biomass and how past policies of the government have been directed at their exploitation to ensure adequate levels of electricity security of supply. This is also in line with the suggestion made in the literature that the strategic planning of power supply is crucial to ensure security of electricity supply (Spalding- Fecher et al 2017). In the case of analysing electricity generated from gas power plants, gas becomes a critical issue of concern in terms of costs, environmental and social factors.

Generally, the literature separates gas from power. That is, the availability of gas does not necessarily mean it will be transformed into power. There are various options at the disposal of government to the use of gas resources which include, power, agriculture, manufacturing and household use (Fritsch and Poudineh 2016). The literature recognises the trade-offs that exist amongst these options and the rationale for their choices. The underlying gas law, host country-oil company agreements may also affect the viability of gas- power projects. Specificity of gas projects also contribute to the various choices (Fritsch and Poudineh 2016).

The elimination of capacity shortness may appear to be simple or naïve if it is argued that the country should simply increase its capacity by investing in gas and alternative power generation plants, and set up regasification plants to support the production of the needed power (Thurber and Chang 2011). The critique is that the entire gas-to -power value chain consists of a series of projects and contracts which should critically be examined and their possible implementation evaluated. There is also the empirical evidence from gas-rich countries such as Nigeria, Ghana's neighbour that is also experiencing capacity shortness (Edomah et al 2017). This implies that there is the need for energy law and policies to transform the gas resource to electricity. Again there is the need to link resource law and policy with power generation from renewable and non-renewable sources to achieve the expected level of security of electricity supply.

Heffron and Talus (2016) distinguish energy law and policy from resource law and policy by arguing that the distinction rests essentially on the idea that energy law and policy are about markets, security of supply and efficiency while resources law and policy is about the strategies used by governments to maximise revenue and exercise sovereignty. Again while energy law and policy is focussed on government policies aimed at securing energy sources at the least possible cost, including social costs, resources law and policy is also related to a country's more general development policies, such as industrial policy.

Therefore, the role of government and public policy is more central in this area of law and policy (Heffron and Talus 2016b). This implies that the regulatory framework, the design of the power market of any developing country, the degree of unbundling and the focus on investment attraction with or without the role of government are extremely crucial to ensure the development of the electricity sector (Massie et al 2015).

Ajayi et al (2017) present a clear distinction between measures that have taken in various jurisdictions that are capacity surplus and those that have transited from being capacity short to capacity surplus by distinguishing between privatisation, deregulation, and liberalisation. Privatisation is defined as the conversion of state owned or publicly-owned utilities into investor owned utilities. Deregulation involves the decision by government to step back from the day-to-day determination of pricing and investment decisions (Ajayi et al 2017). The alternative to direct government control is to appoint a regulatory agency which is independent but accountable to government and which is responsible for regulating the natural monopoly aspects of the industry which arise from the importance of economies of scale and scope. Liberalisation involves the opening of the market to new entrants and the permission of incumbents to demerge into competing firms or alternatively to merge or even exit the industry (Ajayi et al 2017). These forms are not synonymous with each other and may occur to varying degrees in the power generation industry at different times. Ajayi et al (2017) further show that in Scandinavian countries publicly owned utilities exist within a deregulated and liberalised market and in Germany there are many municipal level publicly owned utilities within a deregulated and partly privatised market for power networks.

The literature also has evidence of countries that are gas-poor but have a capacity surplus. This is supported by evidence from Singapore, South Korea, Japan and Taiwan (Li et al 2016). These countries have other sources of electricity developed like the existence of nuclear plants, wind energy among others. This is particularly so with developed or industrialised countries.

Ghana's case is different and presents a case for research because it is a developing country, its gas reserves are growing, it intends to industrialise, and its energy policy on electrification aims at achieving a100 per cent accessibility by 2020(Ministry of Energy 2010). Again Ghana intends to be the energy hub of West Africa and sees energy trading and export as an industry for employment creation through a targeted legislation (Ministry of Energy 2010). These objectives can be achieved through the industrialisation of renewable power generation infrastructure development such as solar power panels and cells manufacturing or related products and facilities. Using the Danish wind energy industry as an example from the empirical studies by Heffron and Talus (2016b), they showed the impact of the theory of targeted legislation. They supported their argument with the following: that the Danish wind industry's installed capacity stood at 3134MW in 2007 and out of this installed capacity, 423MW is offshore. Wind power generated 20% of electricity production in 2007and the Danish wind turbine industry employed 28,000 persons and sold turbines for €7 billion in 2008. Most of the turbines are exported and the Danish wind turbine industry serves 30% of the world market (Heffron and Talus 2016b). Ghana can therefore replicate the Danish example. More importantly, Ghana has the option to improve its capacity shortness. The aforementioned reasons can be critiqued as a mixture of real facts, policy speculations and political wishes.

The rationale for using Ghana in this study is that Ghana has unbundled, liberalised and deregulated its electricity sector for more than 20 years since 1997. Secondly, it has internalised the use of its growing gas production and reserves since 2012 for the thermal plants as a way to eliminate the fuel supply risks for independent power producers (IPPs). Ghana, in addition offers all the necessary investor protection guarantees and stability assurances to all investors. However, the power sector is almost insolvent and the country is still capacity short. Comparatively, the same period was used by many Latin American countries such as Peru, Bolivia and Argentina to achieve full capacity levels (Banal-Estañol et al 2017). Again the average electricity price per kilowatt hour is amongst the highest in Sub-Saharan Africa and belongs to the second top tier group of countries having a high average tariff for power consumption in kilowatt hour (Arlet 2017).

In order to provide a basis for this investigation, this study initially examines the literature on the electricity security of supply and the relationship it has with the regulatory structures in the Ghanaian power sector. It is therefore useful to introduce a definition of electricity security of supply.

1.2 ENERGY SECURITY AND ELECTRICITY SECURITY OF SUPPLY

Electricity Security of supply (ESoS) or the security of electricity supply (ESoS) as a concept has several dimensions, one of which is system adequacy. This refers to the existence of a system or sufficient generation and transmission capacity to meet the load, whether under normal or unusual conditions, such as the unavailability of facilities, unexpected high demand and the low availability of renewable resources. The security of supply for electricity in the UK and France is presented in terms of both capacity margin and loss of load expectation (LOLE)(Tangaràs 2018) . Capacity margin has commonly been used as an indicator of security of supply by the electric utility industry and estimates the excess of available supply capacity over peak demand. LOLE is a widely used security of supply criterion that quantifies the average number of hours per year in which the available supply falls short of the demand (Castro 2017).

The IEA (2016: 97) stresses that electricity security of supply is a broad notion comprised of three building blocks: the security of fuel (i.e. the availability of gas/coal/nuclear/hydro to generate electricity); security of system operations (avoiding blackouts); resource adequacy (avoiding load curtailment in the case of capacity shortage).

The study of electricity security of supply involves the study of other aspects of energy like oil, gas, geothermal, nuclear among others due the diverse ways that electricity can be generated. The security of electricity is an integral part of energy security and encompasses the range of disciplines in physical sciences and engineering within which energy security is rooted, as well as the full range of timescales which energy security operates usually addressed in the social sciences literature (Cox 2016). Again the conceptualisation of low –carbon, secure and affordable electricity systems is the emerging new paradigm in energy security (Cox 2016).

Considering that security concerns are highly correlated with national contexts, it would be useful to explore conceptions of energy security within particular national contexts (Blumer et al 2015) in order to discover what aspects of energy security are felt to be most important to key experts within a policy jurisdiction, and to assess empirically the question of what energy security actually means within that jurisdiction. In this way, instead of simply stating that energy security means different things to different people, it becomes possible to get a grasp on actual perspectives, exploring in particular the existing policy context of the imperative for a secure, affordable and low-carbon system (Cox 2016).

Traditionally, energy security has been integrated in international relations (IR) theories. International relations theories provide four channels or approaches to energy security. The first is the rational approach which posits that vulnerabilities to energy security arise from the structural imbalances between energy producing and consuming regions. An energy crisis is a result of a failure to ensure energy security. From the exporter's perspective, an energy crisis takes place when the exporter is unable to sell its energy at affordable prices so that it can pay off investment costs and create profits. However, the persisting thirst for energy means that such cases remain limited and marginal. It is far more frequent for importers to be denied supplies for a mix of political, economic and technical reasons. An energy crisis erupts when energy resources are scarce, when producers are (perceived as) unreliable or when the prices rise to an unsustainable level (Proedron 2012: 5).

The second is the institutionalisation approach which argues that the failure of cross-border energy trade is due largely to the efficacy of institutions governing and regulating this trade. The core idea is that institutions (stemming from norms and regular practices) build the basis for the stability and security of economic relations. The process of legalisation of international relations stems from the juridical idea that the respect of law leads to a better security. In the electricity sector Roques and Finon (2017) argue that three parallel strands of neo-institutionalism namely: the rational choice, historical and sociological or organisational institutionalism determine the dynamism of regulation and industrial reformation. Schmidt (2010) proposes that discursive institutionalism should be recognised as a distinct approach that directs greater attention than the other three institutionalisms to the role of ideas and discourse in shaping political outcomes and institutional change (Andrews- Speed 2015). At the centre of analysing the institutional framework for the research is Williamson's integrative scheme which identifies three levels of institution. The first is the embedded institutions which relates to the norms, beliefs and ideas. The second is the institutional environment which also relates to the political system, bureaucratic structures of government, judiciary, legal system, property rights etc. The third relates to the institutions which govern transactions such as firms, bureaus, markets, hybrids and networks. It also includes policies, laws and instruments. The conventional transaction cost economics focuses on this level of institutions (Williamson 2000).

In the area of electricity security of supply, the rational choice assumes actors are rational and focuses on social efficiency which includes transaction costs arising from the renegotiation of contracts given the uncertainty in the future, to explain the existence of long term contracts to deal with relational challenges in energy transactions as opposed to standard contracts in the energy sector. Historical and sociological institutionalism help to explain the variety of liberalism reforms in terms of the differences of institutions and the development between countries as well as the steps to establish the initial structures and regulation of the electricity industry.

The third approach deals with the new political economy of energy characterised by technological innovation in power generation, deregulation, globalisation, the integration of power markets, reformations in the upstream petroleum contracts and fiscal petroleum design changes. The reaction to these changes has been the development of international energy financial markets leading to the development of mechanisms for price discovery to manage price vulnerabilities through complex trading and hedging techniques, the rise of stabilisation clauses and international and bilateral investment treaties (IITs and BITs) to provide security for energy sources. In the electricity sector, the existence of market incompleteness, the nature of the product and its value-chain characteristics, limit the use of long –term hedging instruments (De Maere d'Aertrycke et al 2017). BITs are needed to provide confidence and serve as an instrument to attract private capital or investments through private equity firms (Massie et al 2015). BITs are one of the three primary forms of international investment agreements (IIAs).

The second is multilateral investment treaties (MITs) such as the Energy Charter Treaty (ECT) signed between 50 European and former Soviet states specifically on energy investments. The third is free trade agreements (FTAs) such as the North American Free Trade Agreement (NAFTA) between the United States, Canada and Mexico.

These agreements aim to promote and protect certain foreign investments and investors of other states. The protected 'investment' generally is defined to include, among others, shares, licenses, contracts, concession agreements and liens. The substantive protections offered by such agreements generally include protection against unlawful expropriation, unfair and inequitable treatment and arbitrary and unreasonable treatment. In the case of Rurelec vs Bolivia, Bolivia expropriated a British Company's private equity investment in a power generating company. The claimant commenced an ad hoc arbitration pursuant to the US-Bolivia BIT and UK-Bolivia BIT and the tribunal ultimately awarded the claimant US$ 35.5 million in 2014.

The fourth is the non-liberal approach towards energy security. It first considers the four primary structures that shape global economic and political behaviour of states, firms and other socio-economic actors. The four structures are security, finance, production and knowledge. Energy is seen as playing a vital role for production (especially in the industry, residential, and transport sectors), financial (in terms of the benefits provided especially by the oil trade), knowledge (related to technological development, including energy and environmental sectors), as well as security (setting up international institutions dealing with energy supply or direct intervention in oil-producing regions)(Strange 1980). Therefore, full liberalisation gives grounds to discuss the role of the private sector in ensuring energy security.

1.3.0 POWER MARKETS

A market consists of buyers and sellers. In the electricity sector it comprises of the players in its value chain, namely the suppliers of inputs, the generators, the grid system, distributors and the consumers. The composition of the market and how it is structured determines how it can be assessed in terms of performance, competitiveness and satisfaction of its social objectives.

Market structure is one of the key external governance mechanisms that can impose discipline on infrastructure to improve performance and has the major effect in shaping all other key decisions including the design, structure of contracts and decisions on prices (Vagliasindi and Besant-Jones 2013). The nature of electricity makes it difficult to store, requires huge investment upfront, huge physical infrastructure being installed, and has some unique social importance. These characteristics mean that the traditional assumptions under markets will not hold. Again the outcomes have led to the initial monopoly structure and therefore the need for governments to have their power markets regulated (Dahl 2015). In the absence of regulatory pressure, the energy sector, by its very nature, is resistant to informational mobility (Zaman and Brudermann 2018). Therefore, regulation is important to ensure that energy-related information exchange between users and holders of information on a voluntary and self-regulatory basis is at play to establish fair and transparent decision-making processes in delivering reliable energy services (Florini and Saleem 2011).

Regulation can be under the direct supervision of a ministry generally the Ministry of Energy of a country or through an independent regulator. Regulations at the sector level are also important in ensuring security of supply (Petitet et al 2017), protecting the consumers (Nepal and Jamasb 2015), and more importantly ensuring energy justice (Haffron and Talus 2016b). The establishment of energy regulators has been the most widespread power sector reform element (Hayland 2016) and particularly in Sub-Saharan Africa (Kapika and Eberhard 2013), with more than half of the region's countries having such an agency and independent regulatory authority.

An independent regulator brings with it oversight capacity and could potentially enforce the competitive procurement of IPPs. This has unfortunately not been the case in many Sub-Saharan African countries, and we are increasingly seeing that regulatory risk serves as a further disincentive to investment. Merely having a regulator is thus not sufficient; rather, it is the quality of regulation produced and enforced by this regulator that is critical for attracting private investment (Eberhard et al 2017). Given the plethora of stakeholders in the electricity sector which naturally include the government, consumers, investors, utility firms and international organisations such as the World Bank because of the increased focus on the green growth movement and the associated ecosystem services issues (Prévost and Rivaud 2018), the regulators in many jurisdictions are mostly mandated with wide-ranging statutory powers. These institutional powers are broadly aimed at promoting competition, efficiency, consumer protection through the provision of electricity security. The regulators can achieve these aims by engaging the players in the power value chain to provide quality power services and also manage their complaints. In addition to the regulatory function, the laws establishing these regulators such as the Energy Commission Act, 1997, Act 541 in Ghana for example requires the regulator in the electricity sector to : 1. promote competitive and fair market conduct; 2. prevent misuse of monopoly or market power; 3. facilitate entry into and exit from the relevant markets; 4. ensure consumers benefit from competition and efficiency; 5. collaborate with the Public Utilities Regulatory Commission (PURC) of Ghana to protect the interests of consumers with respect to reliability and quality of electricity supply services; 6. collaborate with the PURC to promote economic efficiency, fair, transparent and competitive operations in the electricity supply industry and 7. collaborate with the PURC in facilitating the maintenance of a financially viable electricity supply industry.

As stated in the License and Permit Application Manual for service providers in the Electricity Supply Industry Regulation (2017) in Ghana ,the Energy Commission is further required to ensure the safe and efficient generation, transmission, distribution and sale of electricity in the power system by establishing and enforcing: 1.proper standards of safety, reliability and quality in the electricity supply; 2. proper safety and technical standards for electrical installations; 3. standards to ensure efficient electricity end-use practices and promote productive uses of electricity.

In principle, effective regulation follows or should be determined by the choice of the electricity structure (Lin and Purra 2019). A comparative review of the authority of regulators globally show that they are also required to propose

tariffs and adjustments to the government electricity pricing authority as in China(Lin and Purra 2019) or policies in relation to the generation mix as in the Mediterranean zone (Cambini and Franzi 2013), with the aim to protect consumers as in Australia(Handerson 2014) and in the UK(Newbery 2015; Castro 2017) and to investigate market violations in the European Union(Petitet et al 2017;Hawker et al 2017) and in China(Lin and Purra 2019).
Many of the regulators are mandated to implement significant marketisation initiatives in price transparency and liberalisation, anti-trust measures, experiments in spot markets depending on the governance structure as found in Brazil (Signorini 2015) and information sharing among market players (Rious et al 2015) as in the European Union (EU) and expansion of renewable energy sources as in China (Lin and Purra 2019) and in Germany (Tangeràs 2018). There are some variations in terms of the focus of the regulator in question whether the jurisdiction is capacity short or surplus. Rious et al (2015) show that the in capacity surplus countries, the focus tends to include solutions to address the peaking unit missing money issue. This issue includes a range of market arrangements, such as the introduction of a strategic reserve of power plants owned (e.g. in Finland) or contracted by the system operator (e.g. in Belgium), capacity payments (in Italy or Argentina) or capacity markets (in different markets in the USA, in PJM, ISO-NE or NY-ISO).

In capacity short countries like Ghana the focus is on attracting investors to eliminate the gap in generation, the financial efficiency of generators and the existence of subsidies which do affect the fiscal space of the government and therefore the expected effectiveness of regulatory functions.

The market structure also affects the performance of firms in the power sector. If poor decisions are made on the electricity market structure- technology and the timing of investment- cost increases will be passed to consumers with negative consequences for economic performance and social welfare. The traditional market structure has been a vertically integrated monopoly. The rationale had been efficiency, economies of scale and huge investment requirements for infrastructural development.

The alternative market structure has been the unbundling of the sector with the aim to enhance transparency and governance, attract private sector investment, and to create a competitive market and ultimately its impact on performance (Eberhard et al 2017).

Joskow (2008) says that the standard prescription for successfully reforming the electricity supply industry includes the privatisation of formerly state-owned and vertically integrated monopolies to create incentives for performance improvements. He argues that the vertical separation (or unbundling) of the sector aims at preventing cross-subsidisation among various industry segments and also allowing for equal access to the networks for all competitors. The horizontal restructuring of the generation segment is further suggested to allow competition in power production, and the integration of transmission facilities with network operations to create an independent system operator (Hayland 2016).

Several structures exist around the world. Vagliasindi and Besant-Jones(2013) distinguish six structures including:1. vertical unbundling without horizontal unbundling (but not the reverse); 2. partial vertical unbundling(generation and transmission separated from distribution , generation separated from transmission and distribution); 3. full vertical and horizontal unbundling in generation(and integration of transmission and distribution); 4. vertical unbundling in lesser forms than ownership unbundling, such as accounting, management, and legal(holding company) unbundling; 5. the unbundling of retail supply from distribution and then some reintegration of generation with supply for risk management, keeping transmission and distribution unbundled; and 6. the unbundling of generation services in wholesale power markets. Several OECD countries (Greece, Portugal, Iceland, Korea, Mexico) are still at the initial restructuring stages since they have opened their electricity markets to meet minimum requirements of the electricity sector, while other member states (UK, Germany, Norway, Finland and Sweden) have acted as pioneers in the liberalisation process and pursued strategies focusing at full market opening and the introduction of effective competition in the generation and supply segments (Polemis 2016).

In Sub-Saharan Africa (SSA), Eberhard et al (2017) identified four main structures: vertically integrated with no private sector participation; vertically integrated with private sector participation; vertically unbundled without private sector participation; and vertically unbundled with private sector participation. Ghana’s power market structure is vertically unbundled with private sector participation from independent power producers or projects (IPPs). By definition, IPPs are investment transactions regulated by the underlying contracts. Within this strategic group with a similar power market reform are Angola, Kenya, Nigeria, Uganda and Zimbabwe.

A key feature of power generation procurement in Africa is the low recourse to competitive bidding, despite the fact that this is frequently enshrined into legislation. A minority of IPPs in SSA, excluding South Africa, have been competitively procured: only 16 competitive tenders versus 34 directly negotiated projects. This is partly due to the first IPPs being procured in reaction to power shortages (in all five case study countries they studied), in contexts where capacity planning was weak. In contrast, competitive tenders require good planning, procurement and contracting frameworks – and often impose higher transaction costs. They have, however, delivered better price outcomes than directly negotiated power projects, even in situations with too few bidders. Competitive tenders are also more transparent, providing better investment certainty and less chance of corruption (Eberhard et al 2017). More than two decades of experience in power procurement in Sub - Saharan Africa have demonstrated that a lack of competition in procuring new generation capacity has extensive drawbacks, ranging from the immediate effects on project outcomes (higher prices, unravelling contracts, and so on) to more general effects on the overall governance of the electricity sector and its investment climate. Despite this, we see both forms of procurement used relatively consistently from 1990 to 2014, with no clear move away from or towards either direct negotiations or competitive bidding (Eberhard et al 2017).

Sub-Saharan African utilities are often not credit-worthy off-takers, struggling to keep the lights on and unable to increase capacity (Eberhard and Shkaratan 2012). The aim of power sector reform in developing countries is primarily to improve utility performance – both technical and commercial - and in the process attract more investment, to provide sustainable, affordable, adequate and reliable services for all, and power economic growth (Gratwick and Eberhard 2008).

The unbundling of generation from transmission and distribution was initially understood as a key reform element, and one that arguably should even precede the introduction of IPPs to ensure fairness in the contracting and dispatching of IPPs (versus the utility off-taker's own generation). However, nowhere in Africa is full wholesale or retail competition in place (Kapika and Eberhard 2013). Instead, one finds various hybrid models – where public and private investment co-exist – implemented across the continent. IPPs are found in very different market structures with no clear correlation between the level or sequencing of reform and IPP investment. The majority of IPPs are in fact found in countries with vertically integrated utilities (Eberhard et al 2017).

1.4.0 CONTEXT OF THE STUDY

This section analyses the motivation for reforms and the current power market structures (i.e. the structure and complexity of the electricity value chain) globally. The regulatory and market dynamics facing the Ghanaian power sector are further discussed.

Hayland (2016) argues that ideological reasons were principally behind the reforms in the United Kingdom, Norway and New Zealand among others. Florio (2013) suggests the need to expand the internal electricity market as an additional motivation. A number of political, financial and technical factors converged and started to undermine the logic that the electricity industry should be handled via a vertically integrated (and usually state owned) monopoly (Gratwick and Eberhard 2008). Joskow (2008) argues that the development of gas-fired combined cycle gas turbines(CCGTs), improvement in information and communication technologies, questions about the efficiency of vertically integrated utilities(whether publicly owned or regulated by the public) and poor performance of existing utilities especially in developing countries accounted for the reforms. The advent of highly efficient CCGTs made it possible to build small units in a relatively short time with little risk, which eliminated the significant barriers that had previously existed to entry in power generation.

However, electricity reform in most developing countries was a fundamentally different undertaking from the reform in developed countries in terms of motivations, sector conditions and institutional context (Erdogdu 2011). In developed countries, the main targets of the reform have been the improvement in the economic efficiency of the sector; encouragement of inter-regional (or cross border) trade, the transferring of investment risks to the private sector and offering customer choice. Other subsidiary motives include the demonstration effects of the pioneering reforms of the power sectors in the UK and Norway in the early1990s; and rapid changes in technology especially in the generation of electricity that made new industrial structures possible; the desire to overcome what might be called sub-optimal regulation; and the policy objective to eliminate the tendency to over- invest (so called‘‘gold-plating’’) (Erdogdu 2011).

On the other hand, in developing countries, the motivation for reform included the poor performance of state-run electricity operators in terms of high costs, inadequate expansion of access to electricity services and unreliable supply; the inability of the public sector to meet the investment and maintenance costs of the electricity industry associated with the increasing demands for power resulting from economic development. There is also the need to remove the burden of price subsidies (so as to release resources for other areas of public expenditure), low service quality, low collection rates, high network losses. Furthermore, there is the desire to raise immediate revenue for the government through the sale of state assets. Another rationale has been the policy to attract foreign direct investment in the power sector in line with the encouragement of reform by international financial organisations and donor agencies such as the IMF and World Bank (Zhang et al 2008; Di Bella and Grogoli 2017; Eberhard et al 2017). However, in all reforming countries (whether developed or developing), reforms in power markets have aimed at realising two common objectives: (i) the reductions in price-cost margins and (ii) improvements in service quality (Erdogdu 2011).

For a resource rich country, the supply segment is evidently well developed, while for a resource- poor country the transformation and final use segments tend to be more developed (Yao et al 2018). Exceptions can be seen in many developing countries where the resource –rich country supply for domestic use is not developed but well developed for export to resource poor countries.

1.4.2 The Input and Generation Segment

Traditionally Ghana had relied on hydropower generation. The development of hydropower conceptually followed the ladder of energy (Burke 2010) and endowment theories (Kileber and Parente 2015). Burke (2010) shows a national-level electricity ladder which sees countries transition toward coal and natural gas, and finally nuclear power and modern renewables such as wind power, for their electricity needs as they develop. The extent to which countries climb the electricity ladder is dependent on energy endowments. Ahrend (2002) and Brunschweiler (2009) cited in Kileber and Parente (2015) explain the endowment theory on the basis that the evolution of the electricity mix frequently depends on the energy resource endowment leading to an endowment trap.

From that perspective, electricity mix diversification is an alternative way to improve energy security, and can be achieved by breaking the endowment trap. Poor planning led to an irresponsive policy direction under political dictatorship which had a low discount factor for time (Auriol and Picard 2013) and left the country in a state of extreme capacity shortness following the environmental shock from climatic change which caused drought in the late early 2000 to 2004. Irresponsive planning creates problems for the power sector because of the time lag required to complete other hydrogenation potential which exist despite the hydrological challenges.

The immediate response is to go for thermal power not as a result of increase in incomes which makes it affordable because power prices become less income inelastic but as an unavoidable option. The existing hydro facilities have been operating a relatively lower cost and required little subsidisation from the government. With the introduction of thermal power, fossil fuel had to be imported to optimise production. Given the poorly structured recovery mechanism and power access being made a political tool the foundation for the insolvency of the power sector was firmly laid. Foreign exchange constraint had direct impact on the ability of the thermal plants to operate. With increased urbanisation and political pressure new private participation in the form of IPPs have been encouraged not through proper tendering for the capacity market but through direct negotiation and sole sourcing.

The motivation had been the assumption that with the discovery of gas, which under the Model Petroleum Agreement (2000) allows Ghana to exercise its sovereignty over the gas resources and also gas being the main material input, what was needed was the installed capacity to burn the gas. Currently Eni has started gas production from the Sankofa field in the Offshore Cape Three Points (OCTP) Integrated Oil and Gas Project zone, in Ghana. The field will provide 180 million standard cubic feet per day (mmscf/d) for at least 15 years, enough to convert to gas half of Ghana's power generation capacity (Eni 2018).

The OCTP is the only deep offshore non-associated gas development in Sub-Saharan Africa entirely destined to domestic consumption and it will guarantee stable, reliable, affordable gas supplies to Ghana. The project was developed with the support of the World Bank, and it has a strategic relevance: gas from OCTP can help Ghana shift from oil-fueled power generation to a cleaner power source, with financial as well as environmental benefits of reducing harmful emissions, and contribute to the country's sustainable economic development (Eni 2018).

Under this agreement, ownership of petroleum production remains vested in the people of Ghana or the Ghana National Petroleum Corporation (GNPC) in line with various United Nations Resolutions (the UN General Assembly Resolution 626 (1952); the UN General Assembly Resolution 1314 (1958); the UN General Assembly Resolution 1803 (1962); the UN Charter of Economic Rights and Duties of States (1974); and the UN Charter of Economic Rights and Duties of States, UNGA Resolution 3281 (1975)). The model petroleum agreement reinforces Ghana's sovereignty as it is designed such that, when the gas or oil is brought to the surface at the wellhead, the contractor acquires title to its share of the petroleum produced, only as and when the petroleum reaches the export point or a mutually agreed delivery point at the outlet of the field facilities. For example, Section 14(13) and section 14(18) allows the contractor to propose changes in the fiscal and other provisions in the agreement or enter into a new agreement to ensure speedy exploration of the gas reserve identified. However, when the gas is not on commercial basis, the Energy Ministry under Article 14(9) will exercise the right to directly direct the gas for domestic consumption.

A critique of the degree to which the Model Petroleum Agreement provides sovereignty over the gas resources is that the agreement does not have a progressive split based on daily basis or on cumulative production as found in Angola, Equatorial Guinea and Nigeria or based on the profitability of operations. The level of royalty is 5% of the annual Gross Production of natural gas as compared to the 12.5% royalties placed on oil production as an incentive to enhance the viability of a Gas project by encouraging an early cost recovery. It is stated under section 14 (16) and section 14(17) of the Model Petroleum Agreement that aside the allocation to be given to the GNPC based on their share of investment and the state take, the objective is not to create any investor disinterest. The desire to protect and prioritise an investor's interest is highly espoused in the construct of the Model Petroleum Agreement primarily to promote stability of contracts and revenue with guaranteed market without prejudice to an export project. Again the use of domestic supply obligation is not in place under the current Model Petroleum Agreement.

Again the assumption was that the needed grid system to complement increased power generation already exists and can easily be energised to allow for the transmission of power to consumers. The weakness in this positional stance is the fact that plant capacity installation is a project financing issue which should be bankable (Yescombe 2014). Second, physical grid and related network systems need to be synchronised with the production lines to ensure the efficient transmission of power (Parsons 2017). Thirdly the entire financing of the value chain depends on the recovery of funds through tariff collected by the distribution firm (Di Bella and Grigoli 2017). The Electricity Company of

Ghana (ECG) has been privatised in 2019 by the government by allowing for a concessionaire called the Power Distribution Services Ghana Limited (PDS) to take over part of ECG's operations primarily to enhance revenue recovery in the Ghanaian power value chain. Fourth, is that the IPPs are international investors who will be interested in protecting their investments and effectively recover their investments (Eberhard et al 2017)

The bankability criteria will require that risks are allocated to the party best to handle them with further guarantees from the government, which create potential contingent liabilities for the government with possible budgetary and fiscal space challenges. The investor is not concerned about the modus of recovering revenue from power sales to consumers down the chain as far as the purchasing power agreement, standby, confirmed and irrevocable letters of credit and guarantees have been provided by the state. In other words, power is not priced based on cost but by a negotiated rate.

Understanding the role of gas in the electricity input supply segment and gas specific characteristics also need to be considered. It is a non-renewable resource, implying that gas not produced today can be used tomorrow. This adds a dimension of scarcity rent. Similarly, gas has to compete with other fuels at the end-use level, which essentially determines the value it can fetch termed market –based pricing and under this approach, cross-border natural trade promotes gas-to-gas competition. Depending on this value, gas production may yield a resource rent as well. As the investments in transportation and distribution networks are high, inflexible, sunk, durable and investors seek for long-term commitments from consumers. Thus, pipelines need a long-term commitment from the distribution network to buy gas while the distribution networks need a similar commitment from the end consumers. Similarly, producers are not willing to invest in production in the absence of secure long-term contracts. All these features tend to restrict the gas industry to high value users, at least at the initial stage of gas industry development, to ensure finances for investment in infrastructure and production facilities (Stickley 2010).

The next issue relates to the potential for other renewable energy from solar and biomass which if well-developed can contribute to power generation as found in Brazil, but again policy failure has created little room for their effective contribution in the very short to medium term security of supply in Ghana. Therefore, for generation of power the main option is to rely on thermal and hydro to meet the electricity needs of Ghana.

1.4.3 Distribution Segment

The electricity value chain depends on the revenue generated from the distribution and sale of the electricity to the final user. The Ghanaian power users are one of the highest payers for power in the world. For example, comparative tariffs for German and Ghanaian consumers show that in 2016, the average quote per megawatt hour was US$210 in Ghana (Energy Commission 2017) as compared with €36 (US$54) for German users (CEER 2016). Technical, operational and commercial losses total around 30 per cent making collection less than 60 per cent if one takes into account the potential debtors from post –paid customers. This undermines any robust revenue for investments into the power sector.

After 20 years of reforming the energy sector the sector is almost insolvent with a high energy sector debt of over UDS 3.6 billion representing almost 6 per of Ghana's GDP(IMF 2017a), growing government subsidy, a financially weak potential power offtaker for any potential investor in the generation sector supporting the empirical findings by Kashi (2015). However, there is the possibility of reducing these financial exposures through reforms in the distribution sector. These reforms should ensure the creation of an effective metering and billing system, and value-driven customer service channels for bills collection to complement any forward looking regulatory (governance and substance) rearrangements (Swadley and Yũcel 2011; Thamae et al 2015).

1.5.0 CRITICAL REVIEW OF THE GHANAIAN POWER MARKET DYNAMICS

The World Bank in 2011 estimated the cost of providing a standardised infrastructure package in a number of African countries, including Ghana. Meeting Ghana's infrastructure needs would cost US$1.6 billion per year for the next decade or around 10 per cent of GDP. Almost half of the total spending requirement is associated with the power sector, with investment needs for that sector as high as US$600 million per year to double the existing capacity to 4,000 MW by 2017 that would allow satisfying a domestic demand projected to grow by 7% annually (including a small and constant proportion for exports to neighbouring countries) (World Bank 2009). By 2017 the installed capacity has reached 3794.6 MW with a dependable capacity of 3525.1 MW (Energy Commission of Ghana 2017).

The investments potential through project financing in Ghana can be seen from the annualised cost of capacity expenditure at constant access rates with trade expansion in US Dollars as illustrated in Figure 1.1 below. Such power generation and investment gap means that the country's development agenda is being undermined.

Figure 1.1: Ghana's Annualised Cost of Capacity Expenditure, Constant Access Rates Trade Expansion

Generation(US$ in millions)					
	Investment	Rehabilitation		Variable	
Ghana	262	9		32	
Transmission and Distribution(US$ in millions)					
Cross Boarder Grid	Distribution Grid	Urban Connection	Rural Connection	Rehabilitation	Variable
5	79	42	3	34	94
Total Costs of Capacity Expansion(US$ in millions)					
	Investment	Rehabilitation	Variable	Total cost of capacity expansion	
	391	42	126	559	
Source: Eberhard, A., Rosnes, O.,Skharatan, M., and Vennemod, H.(2011: 163) *Africa's Power Infrastructure Investment, Integration, Efficiency.* World Bank Washington D.C.					

Theoretically, full recovery of revenue and investments in the gas-to power value chain could be assumed but needs to be justified as against its use for export, agriculture or industrial production. Ghana has two main options in the short –term to use its gas resources, namely for either export like Nigeria or domestic power production. The alternative use of the gas produced for agriculture and transport are medium to long –term options (World Bank 2013). An assessment by the World Bank in 2013 showed that the use of gas-to-power option is better than the export option. One possible justification could be if its use would bring down the cost of power generation and ensure better security of electricity supply due to domestic input supply reliability. There is also the attraction of more investors due to available inputs to increase power availability and the potential for power export in line with government power sector vision (Ministry of Energy 2011).

The principles of an equilibrium market price determination in economics states that the price of a good or service is determined through the interaction of the forces of demand and supply. Applying this principle of economics under full market condition, in theory capacity shortness can be managed through the interaction of demand and supply (Dahl 2015). Where there exists excess demand over supply, price will increase to eliminate consumers whose marginal utility for consuming power is less than price being charged. The structure of energy demand and supply does not allow for such a smooth play of energy demand and supply sources and the optimisation of taking consumer surplus. There are three driving forces in many developing countries like Ghana.

First electricity or power availability is a political issue and its availability is synonymous with fulfilling key political platform promises made to urban constituents. Primarily there are built –in subsidies inherent in the electricity tariff structure, which takes the form of increasing block tariffs (IBTs) in which a lower unit price is charged within the first consumption block and higher prices in subsequent consumption blocks. The conventional regulatory wisdom is that IBTs are designed as 'lifeline' or 'baseline' tariffs trying to align the first block of low consumption to a subsidised tariff and higher levels of consumption to higher pricing that would ultimately allow for cost recovery.

This assumes that power customers will have lower consumption levels (Eberhard et al 2011). This is a reasonable assumption in the power sector, where consumption is correlated with the ownership of power consuming devices, more of which are owed by wealthier households.

Secondly the price is regulated and the independence of the regulator determines its ability to use regulatory mandate effectively to promote investments into power generation. For any effective promotion of investments, given the degree of capacity shortness, power producers should be allowed to pass through their increased cost due largely to the fall in the exchange rate, and maintenance costs in the power purchase agreements (PPAs). In the Ghanaian context, the government has always agreed to provide the main input the fuel. This also means that liquidity-constraints from the budget and government revenue determine the flow of gas from the West African Gas Pipe (WAGP) or LNG purchases. The other effect is that the market offtaker the Volta River Authority has to borrow from the local banks to settle the letters of credits that go with the gas imports which in turn has undermined the stability of the Ghanaian banking sector due to loan defaults or the restructuring of these energy sector debts. The current energy sector debt stands around US$ 3.6 billion which the government intends to defer short term settlement by issuing energy bonds by the end of 2017.

An additional implication for energy law and policy is the implied energy injustice due to continued exploitation of gas from the gas fields while debts are being shifted to the future generation to pay not for infrastructure but for a product which has been consumed by the current generation. The energy justice principle of intergenerational equity requires that the use of energy resources should benefit future generations (Heffron and Talus 2016b).

Thirdly where energy price generally determines the marginal profits of many small and medium sized (SME) companies, in economies dominated by these SMEs electricity prices tend to be rigid upwards with governments proposing interventions in the form of subsidies.

Therefore, balancing demand and supply requires a strategic approach in terms of design and implementation. Infrastructure availability in capacity short and energy import dependent counties are challenging because they are capital intensive upfront. This requires the proper pricing of electricity which will be adequate enough to cover the cost of inputs and return on investment. Proper pricing although has a short term trade off in terms of political challenges. In the long term proper pricing will provide the necessary resources needed not only to maintain but to improve the generation of power economically and effectively to meet the expected level of security of power supply (Banal-Estañol et al 2017).

In capacity short economies the principal challenge of managing affordability and increasing capacity has been through tariff rebalancing. Providing energy at an affordable price is a related issue to enhance energy access to the poor (Sadath and Acharya 2017). While developed countries have experienced price reductions after reform, the same is not true for developing countries where the prices were subsidised for many consumers. In this respect, it is important to note that commercial energies have to compete with traditional energies for the most important demands such as cooking and heating in poor families. Given the lack of regular flow of money income for the poor due to the existence of in-kind payments for certain services and participation in informal sector activities, the poor would have a natural preference for the fuel that does not involve money transaction or imposes minimum money demand (Sadath and Acharya 2017).

This is difficult to satisfy unless commercial energies could be produced very cheaply, which does not appear to be feasible in practice. An alternative to this could be to ensure sufficient money flow to the poor so that they are willing to spend some of it for purchasing commercial energies. This takes the problem beyond the dimension of energy sector restructuring and puts the onus on overall economic development and wealth distribution. However, this is a long-term issue and cannot be tackled in the short run (Sadath and Acharya 2017).

Tariff rebalancing involves striking a judicious balance between the two regulatory tasks: protecting consumers while allowing a fair chance of recovering costs and earning a reasonable return to the utilities (i.e. ensuring their financial viability). This is another area of major concern in developing countries where tariffs are not cost reflective and non-remunerative. Tariff rebalancing involves establishing cost-reflective tariffs for different consumer categories, by eliminating subsidies and cross-subsidies. This in other words implies that prices should go down for those consumers who are paying more compared to the cost of supplying them, while prices for those paying less should increase.

As any reform intends to bring transparency in the cost and in the decision-making process, the tariff issue becomes complicated. This is because consumers and non-governmental organisations (NGOs) oppose any tariff increases placing the blame on the utility, while the utility cannot survive unless tariffs are rebalanced in a restructured environment with erosion in its traditional cross-subsidy base. For certain categories of consumers, cost-based or market-based tariffs may be established instantaneously (for consumers with less lobbying power). But it is difficult to establish such tariffs for those who have enjoyed such benefits for a considerable period of time in the past or those with significant lobbying power. Moreover, it may not be politically feasible to remove entire subsidies in one stroke.

As indicated earlier, a tariff rebalancing exercise is closely related to performance improvement. The two normally act in the opposing directions: the average prices should increase when subsidies are removed while improved performance tends to reduce the average prices. If subsidies are removed at the beginning of the reform when the performance is still poor, prices could be expected to decline in real terms once the utility improves its performance. However, such an instantaneous rebalancing may be very unpopular due to price shocks (which regulators tend to avoid as a principle) and may create enemies of reform. Politically such a strategy may be suicidal as well. The objective of the phased tariff rebalancing programme is to manage the transition in such a way that there is no tariff shock to consumers but at the same time the utility remains in business. As the utility may not be recovering full costs in a phased programme, either state subventions or alternative financing arrangements of the revenue gap will be required. Regulators use the concept of “regulatory assets”, which is a mechanism of recognising the financial deficit for cost recovery purposes. The regulatory asset is then allowed to earn a return to ensure that the cost of carrying the deficit is financed. The regulatory asset is retired over a period, by allowing charges (similar to depreciation or loan repayment).

Government through its primary and secondary legislative instruments should specify among other things the initial regulatory asset base, the mechanism for rolling forward the asset base, the role of efficiency benchmarks, the criteria for assessing efficiency a timetable for removal of cross-subsidies and price/service guarantees for specific consumer groups(Brown 2004:4).

More importantly, is the need to balance the interests of investors into the power sector due to the ‘missing money’ (De Maere d’Aertrycke et al 2017) and their perspectives should guide policy direction on PPAs. Pricing should be based on a long term contract for the sale of power project output at an agreed price with the offtaker (VRA) with the ‘availability’ based tariff structure. In addition, there should be limited offtaker termination provisions with termination payments structured to repay senior debt and equity plus an agreed return on equity in particular scenarios. Additional support arrangements to cover a backstop offtaker payment should be in place (Massie et al 2015).

1.6.0 MOTIVATION AND RESEARCH PROBLEMS

Following the lead of the existing literature, notably Erdogdu (2013), Deakin et al (2017) and Prévost and Rivaud (2018) the new institutional economics (NIE) which has influenced the analysis of institutional arrangements and legal issues becomes one of the main theoretical frameworks for the research. Its main thrust is that, states should develop strong regulatory mechanisms to encourage legal accountability, minimise corruption and foster competition via privatisation. Erdogdu (2013) defines NIE by citing Chavance (2009) who explained that NIE is a body of economic thought that considers institutions to be relevant to economic theory and criticises the neo-classical mainstream for having pushed out of the discipline. In other words it deals especially with the nature, origin and evolution of institutions, and their effects on economic performance. Prévost and Rivaud (2018) stress the need to integrate the two branches of NIE, namely: the neoclassical institutionalism and pluri-disciplinary and historical analysis of institutions and law. The NIE maintains that where property rights are not clearly defined in the course of an electricity market reform, transaction costs increase and reforms may fail.

The 20-year period of power market reforms in Ghana has resulted to a huge energy sector debt, capacity shortness and imbalances between the fiscal, legal and regulatory requirements and demand management which contrasts with the empirical evidence from Peru, Bolivia and Argentina for example (Banal - Estaῆol et al 2017).

The comparatively poor performance of the Ghanaian electricity sector leads to the research problem of whether the specific and general institutional endowments (such as judicial independence, the integrity of the legal system, protection of property rights, legal enforcement of contracts and degree of polity) and regulatory institutions that support the electricity reforms in Ghana can explain the level of electricity security of electricity (ESoS). Erdogdu (2013) further argued that electricity market reform is an institutional reform that necessitates de facto or de jury regime change, the creation of new institutional structures and the rearrangement or removal of existing ones. By using the pluri-disciplinary and historical analysis of the electricity sector to examine the existing reforms, their design, quality and effectiveness, the research problem advanced or identified in this work or study relates to the policy missteps if they exist and how they deviate from the functional policy guidelines from the New Institutional Economics (NIE) paradigm (IMF 2018; Prévost and Rivaud 2018).

A complementary argument also emerges from the spontaneous conceptions of law and property rights that downplay the role of the state (Deakin et al 2017). Law is a key institution for overcoming contracting uncertainties and therefore there is the need to understand how the Ghanaian legal framework and regulatory structures support the development of institutions that promote the elimination of the country's capacity shortness, high level of electricity security of supply (ESoS) and the power sector's long term sustainability (Deakin et al 2017).

If legal institutionalism places particular emphasis on the role of the state, then the research is motivated by the need to critically assess the effectiveness of government policies in relation to Ghana's electricity market reforms. With the role of the private sector through privatisation, deregulation and liberalisation, there is the need to manage the complex system for processing information and allocating and protecting rights to tangible and intangible assets (Deakin et al 2017).

This thesis is further motivated by the following reasons. First, empirical studies (Apergis and Danuletin 2014; Atems and Hotaling 2018) show that economic growth and development are centred on the availability of power. Practically and from the empirical literature, electricity has diversity of sources of input supply (Hunt et al 2018). Ghana is fortunate to have a growing domestic gas production which if economically managed can be justified to support its use for power generation. Recently, natural gas has gained prominence for non-transport uses, such as power generation, due to its availability, flexibility, portability and low cost of plant construction.

In addition, natural gas has the advantage of 50 per cent less carbon dioxide in comparison with coal and 25 per cent less than gasoline (Stickley 2010). In other words it is cost and environmentally friendly. Natural gas production, gathering, processing, transportation and distribution have been treated separately from its application into gas –fired power generation despite the fact that power generation is the main driver of natural gas demand growth (World Energy Outlook 2011:28). Natural gas value chain does not include electricity. A power value chain or electricity from gas, involves generation, transmission, distribution, supply and metering.

Traditionally electricity from gas relies on the assumption of available gas input either imported or produced locally. This model suits economies that have surplus electricity capacity as such dichotomy provides room for restructuring and deregulation finally to generate competition, efficiency, market transparency in an evolving but mature and sanitised regulatory framework. It is this model or approach to modelling the natural gas and gas to electricity sectors which have been applied globally with limited consideration to capacity short but gas resource rich developing countries with the expectation that over time capacity will match rapidly increasing demand due to economic, incomes and living standards changes. Juxtaposed to the transitional industrial age where the capacity expanded through the use of coal, hydropower and nuclear, these developing countries are expected to go through that energy developmental stage to mitigate the capacity shortness which is to say that ‘a particular shoe should fit all sizes’.

Again, where there is adequate gas generation the assumption was that of ‘build the infrastructure and the investor in power plants will automatically come’ to connect the gas and power supply to eliminate the shortness (Thurber and Chang 2011). Evidence shows that this has not worked in countries where governments have made such assumptions as they still have electricity shortness to grapple with. Nigeria exemplifies a country with abundant gas supply but is capacity short (Edomah et al 2017). The lessons are that the existence of gas does not mean that electricity will be generated for the market. Secondly, where gas is abundant gas can mean electricity if the complexity of gas and electricity generation are properly integrated. Thirdly, because gas is a natural resource, the issue of ownership of its generation brings into question the legal issue of sovereignty and investor objectives (Gao 1994; Duval et al 2009). The need to balance their conflicting interests is necessary to practically incentivise investments required to move the gas from the ground, have them transported, transformed into electricity, distributed and monetised.

However, these developing countries need to attract both domestic and international capital to eliminate the capacity shortness. Investors who are also conscious of risks in investing in the gas-electricity value chain in developing countries have placed reliance on contracts, including purchase power agreements(PPAs), to mitigate transactional risks and contract stability as the bellwether of project success and government credibility. Power or electricity has the two unique characteristic of being undifferentiated and not storable (Sally 2002).

The combined effect leads to the central argument that the traditional approach to using only incentives to manage gas and electricity risks separately has to be done differently when it comes to capacity short and gas resource rich economies.

Theoretically gas has been separated from electricity because natural gas has its value chain which does not necessarily end up in power or electricity generation. However, the main driver of gas development is power generation.

Power generation and risks are very diversified but a close relationship can be established between gas production and power or electricity supply or production. A striking, yet little explored factor for promoting investments in the power sector is transparency in fuel markets (in this case domestic gas availability) (Woodhouse 2007). Investors are highly attuned to the risks that may flow from fuel supply arrangements, both because of the price of fuel is the principal cost component of electricity and because fuel markets offer fertile grounds for manipulation and opportunism (Woodhouse 2007). However, the topic has not attracted significant scholarly attention, leaving the field with a vast body of anecdotal experience but little systematic analysis (Woodhouse 2007).

A critical look at this relationship will lead to three typologies in the form of: net gas importer, gas power dependent and capacity surplus; net gas exporter, gas power dependent and capacity surplus; and net gas exporter/ importer, gas power dependent and capacity short. The third typology exemplifies the 'paradox of plenty'. Nowhere in the world exists an abundance of electricity generation resources but produces and consumes least electricity than in Sub Saharan Africa. Blackout and brownouts are the order of the day. The cost to the economy of load shedding as a demand management tool is equivalent to 2.1 % of GDP on average (The World Bank Group 2013). Public desire or interest is to eliminate the power shortages and have a sustainable electricity security of supply.

Therefore, another motive for the thesis is the recognition that the financing of the entire value chain of electricity generation comes from the price paid for electricity, which inherently creates market risks for potential investors. These risks manifest in the form of the price received for a kilowatt hour (kWh), the timing of revenue receipts, the currency of payment and the readiness of the government to translate or accept puttables in the power agreements into convertible currencies as a window to secure investment recovery for investors. Evidence shows that price per kilowatt of electricity in Ghana is one of the highest in the world (Eberhard et al 2016). The motivation is how the entire power value chain, notably the gas-to –power value chain and the power market can be engineered to reduce the excess economic rent to the benefit of all stakeholders. In theory, price regulation in the form of price-cap formula of retail price index less plant efficiency (RPI-X) implies that improved efficiency can be shared amongst shareholders. For example, the Government of Ghana through the Public Utilities Regulatory Commission (PURC), has announced a general reduction in electricity tariffs effective March 15, 2018. Residential customers per the new tariff cuts are to enjoy a 17.5% reduction, while non-residential customers will see tariffs cut by 30%. Those in the mining sector have also been given a 10% tariff cut, and 25% cut for special load tariff customers consisting of the low voltage, medium voltage and high voltage users. The reduction in prices was due to contractual price renegotiations with power generators notably with the IPPs, not as a result of efficiency gains and changes to the taxation of electricity services.

The additional motivation is the security and sovereignty components arising from the absence of domestic supply obligation of the gas produced in Ghana (Model Petroleum Agreement 2000). In short, the imbalances in the demand and supply of power have generally been taken for granted that it would be solved once funding is made available. However, the elimination of this capacity shortness demands radical shifts in institutions, systems and more importantly legal frameworks that can lead to openness, transparency and the complete overhaul of investment flow or allocation into the entire power value chain.

Another motivation is the development of electric cars which countries notably China, Netherlands and Norway are positioning themselves to be the world's leaders and to benefit from reduction in emissions (Bloomberg New Energy Finance 2016). Because the main means of transport in Ghana will remain road transport in the nearest future, electricity demand and sales for transport is likely to be easily adopted in many developing countries like Ghana similar to the adoption of mobile technology. This also places electricity generation at the heart of downstream energy distribution and its availability for the transportation sector. Therefore, energy nationalism based on the lessons from the telecom sector in Ghana makes the research strategic in perspective. In addition the Dickson (2017) submits that demand for metal for electricity notably aluminium and copper will increase with the use of batteries for the transport sector. Ghana has huge bauxite and manganese reserves which require that the related value-adding processes for the future growth of the economy are intertwined with the electricity security of supply.

Another motivation is the strategic importance of adopting a proper generation mix through a proper sequencing of reforms in the power sector. The sequencing of privatisation, deregulation and liberalisation in capacity short economies takes a different trajectory that is quite distinct from either a resource –poor or rich but capacity surplus economies (Ajayi et al 2017; Yao et al 2018). Supply must simultaneously match demand. Therefore, the security of supply – the insurance that when the light switch is operated, the lights come on- is a systems property in a capacity full environment, with important public-goods characteristics. Furthermore, an unregulated competitive market would need to sell an insurance product or be allowed to charge very high prices when the margin between supply and demand gets tight. This insurance product probably needs to have a compulsory element, since the incentives to a free-ride would be considerable (because the security of supply is a system property). Such free-riding are implicit in the special arrangements for large gas and electricity customers where interruptible contracts provided marginal –cost of electricity and gas, but supplies were rarely interrupted (Helm 2008:260). Customer choice also needs to be placed in a dynamic context. Investments in new power stations and gas fields have significant sunk costs. Investors need to be able to manage the risks that these may become stranded. Under monopoly customers can be tied to suppliers and, hence, to particular generation contracts and this does not hold under deregulation (Helm 2008).

The limitations to consumer choice were also added to by the distributional effects of pricing in electricity and gas. Energy to domestic customers is typically considered a ‘merit good’ (Helm 2008: 261). It is one of the social primary goods which are necessary to participate in society. Along with housing, education, health, transport and food, heating and light play the role of necessary conditions for a minimum standard of living. ‘Fuel poverty’ arises not because people are unable to demand the supplies of their choice, but because they cannot match their willingness to pay with the ability to do so (Helm 2008). To make competition work, the necessary infrastructure for billing and coping with switching is required. Metering is an essential component. In a monopoly system, much of this is very straightforward, and consequently, in principle, low-cost. There is no switching of bills and they can be averaged (and cross-subsidised), and bad debts absorbed within the context of total costs. Purchasing strategies by suppliers are not needed. They supply long-term from the generators at cost and hence portfolio risk management is not needed. Where metering is expensive, it can be avoided through demand profiling and average pricing. A monopoly system should therefore be simple and cheap to run (Helm 2002).

By contrast, competition in supply for generation and distribution requires very considerable information technology systems, extensive metering and contract –risk management. Thus, there are costs as well as benefits to competition. The advocates of liberalisation paid too little attention to these at the outset, and cost-benefit assessment were noticeable either by their lack of sophistication or by almost blind faith place in the idea that because competition was assumed to be more efficient, therefore there would be price reductions sufficient to offset these set-up costs caused by competition. In order to promote competition, while capacity is expanding, very intense regulation for competition would be required, which was much more demanding than the regulation of monopoly. From the neo institutional economics paradigm, markets have to be designed, property rights established (Helm 2002) and policed (Prévost and Rivaud 2018). Again the requisite conduct rules that ensure that environmental risks and ecological scarcities are reduced and accounted for are firmly put in place (Prévost and Rivaud 2018).

1.7.0 RESEARCH AIMS AND OBJECTIVES

The research principally aims to investigate how the principles and functional policy guidelines underlying the new institutional economics have been implemented in Ghana and their effects on the level of electricity security of supply in Ghana. Electricity security of supply (ESoS) is one of the main measures of the energy security of a country (Cox 2016). The quality and level of ESoS may take a path dependency, where an inefficient electricity market persists (Erdogdu 2013).

Therefore, there are five primary objectives. The first is to critically examine the composition and comprehensiveness of institutions that support the Ghanaian power market value chain. The second objective is to evaluate the power market structure in Ghana and how the gas-to –power option supports the security of electricity in Ghana. It also seeks to understand the structural nature of the underlying power generating resources notably gas - to -electricity value chain risks and explore the trade –offs in the various policy options in the areas of regulation, fiscal space and financial arrangements for capacity short but gas –rich developing countries like Ghana. These two objectives are discussed in Chapter 2.

The third objective is, given that hydro and thermal generation are the two main sources of power generation in Ghana, the study explores further whether the contractual type or ownership type of a generator operating in Ghana influences its contribution to the level of electricity security of supply in Ghana. The sustainability measures, plant size and tariff levels received by these producers which define the financial efficiency of firms represent the firm-level risk taking variables (Vagliasindi and Besant-Jones 2013; Eberhard et al 2017), while regulatory reforms and ownership or contractual structures given the bankability requirements for plant establishment are regulatory factors that do affect the level of electricity security of supply (Jacobsen et al 2012; Petitet et al 2017; Roques and Finon 2017). This objective is discussed in Chapters 3, 4, 6 and 7.

The fourth objective therefore, is to examine the relationship between the electricity security of supply and regulatory and power generating firm-level risk factors in Ghana. This objective provides economic and legal grounds to suggest changes to and redefine energy and resource policies, regulations and laws with respect to the rules of satisfying obligatory and contractual principles underlying gas –to- power contracts. The contract related principles which include the authority, validity, contents and effects, performance, remedies, particular remedies, the plurality of parties, the transfer of contracts, the set offs, prescription, illegality and conditions are important because of the positive effects they have on regulatory, financial and fiscal policy decisions in the electricity value chain(Commission on European Contract Law 2002). This objective is discussed in Chapter 5 and also as part of the implications of findings in Chapter 7.

Finally, this research seeks to explore a new paradigm of sequencing of power generation mix policy given the backdrop of growing gas reserves, more hydro potential and the abundance of solar resources in capacity short economies (Gyamfi et al 2015; Saka et al 2017). In keeping with Batlle and Rodilla (2010), the research further examines measures that should be deployed to enhance the firmness, adequacy and strategic expansion of electricity in Ghana, using the empirical evidence of such measures used in Latin America, the USA, UK and EU, while taking into account the complexities in the Ghanaian case. This objective is discussed in chapter 8 of this thesis.

1.8.0 RESEARCH QUESTIONS, GAPS IN THE LITERATURE AND HYPOTHESIS

The research objectives lead to the following research questions:

1. What is the overall level and nature of electricity security of supply in Ghana? The rationale for this research question is that, it allows the author to explore the structural nature of Ghana's electricity security of supply (ESoS) by evaluating the appropriateness of the existing and potential generation technologies (Parsons 2017) given the emerging gas and renewable resource endowments. The research will empirically examine the level of electricity security using the measures adopted by the OECD/IEA (2016) in measuring electricity security of supply globally and Ofgem (2015) in measuring electricity security in the UK (Castro 2017) and adapt them to reflect the Ghanaian situation which is less complex.

The measurement of the nature of electricity security will be centred on the three building blocks suggested by the IEA (2016) which include: the security of fuel (the availability of gas/ hydro/solar to generate power in Ghana); the security of system operations (avoiding blackouts); and resource adequacy (minimising load curtailment given the case of capacity shortage in Ghana). Inherent in these three building blocks are considerations such as sustainability, affordability, profitability, fossil fuel dependency, geopolitics (dependency and vulnerability, socio-cultural factors, access and terrorism) and how the level of electricity security compares with that of neighbouring countries and their impact on energy security in Ghana. The question is similar to some of the themes undertaken in the empirical studies by Dastan and Selcuk (2016) in Turkey; Hawker et al (2017) in the European Union and OECD/IEA (2016) globally. Again the deregulation period from 2007 to 2012 will also be compared to post 2012 measure of electricity security to ascertain the impact of private and development financing institution investments on electricity security levels using both periods. These issues are discussed in chapters 2 and 5.

2. How do the institutions regulating the current power market design and power firm-level risk management practices impact on electricity security of supply in Ghana? The rationale for this research question is that it allows the author to explore the institutional environment, the governance mechanisms and in particular the regulatory governance and regulatory

substance and their impact on the level of electricity security of supply in Ghana. The legal design and institutional arrangements of the Ghanaian regulatory system and processes for regulatory decision making are expected to create the desired credibility to the regulatory agency and also enhance the legitimacy of their regulatory decisions. Again by examining the desired attributes and elements of regulatory substance that lead to quality and robustness of regulatory actions(Thamae et al. 2015), the research will be able to ascertain if such measures have impacted on the level of investment and operating efficiency which directly affect the security of electricity supply in Ghana.

Given the multidimensional nature of regulatory design challenges, Vagliasindi and Besant-Jones (2013) argue that it is likely that no single structure will be optimal for all countries, regardless of the state of development of the power sector and other contextual circumstances.

An effective regulatory design in the Ghanaian context, should take into account how the interests of the hydro and gas-to-power firms including the IPPs have balanced within the political and socio- economic environment as well as the legal and investor interests expected in bilateral investment agreements (BIAs) between Ghana and investor countries. Power sector firms are expected to have complied with reliability, adequacy and environmental risk governance standards required by the regulatory bodies to be disclosed as envisaged in the International Financial Reporting Standards for financial disclosures

(IFRS7); financial assets measurement (IFRS 9); and for fair valuation of assets and liabilities (IFRS 13). This is important to ascertain the degree of indebtedness of state energy firms, their profitability, levelised cost of electricity (LOCE) and any potential stranded costs.

Again, the effect of liberalisation which allows for the entry of IPPs with varied origin with varying contracts and guarantees (Petitet et al 2017) will be assessed. These regulatory measures do not only affect the market structure but also guide the IPPs on their day–to–day activities and risk taking (Massie et al 2015).

The effects of liberalisation and deregulation against the level of demand for power manifest in the size of the power market (Vagliasindi and Besant-Jones 2013), accessibility, affordability and sustainability (Cameron and Stanley 2017). These elements also determine the performance of the Ghanaian power market (Gyamfi et al 2015).

3. Why and how should the elimination of the capacity shortness be sequenced? The rationale for this question is that it allows the author to analyse how the policies implemented to develop the power market value chain have been sequenced and therefore to be able to assess their appropriateness. Another reason is to inherently address the legal aspects of energy project financing, market risks, fiscal and other related financial issues which form the basis for any policy formulation aimed at achieving the needed balance or equilibrium in the conflict of interest between power sector investors and public policy makers.

> This is similar to the recent work by Di Bella and Grigoli (2017) in their comparative study of the Haitian and Nicaraguan power markets. The legal, regulatory, financial and fiscal measures will need to be rearranged or reconfigured given the way in which the process of improving generation capacity levels, grid expansion and distribution of power have been implemented in Ghana.

The gap in the literature has been the exclusion gap arising from sample sizes and variables used in their estimation techniques by previous researchers. Previous studies undertaking a comparative analysis of the power market legal and regulatory frameworks against other countries did capture the influence of the regulation in their models (Jamasb and Nepal 2015; Cox 2016) but excluded Sub-Saharan countries. Likewise that of Vagliasindi and Besant –Jones (2013) however considered the Sub- Saharan countries but did not include Ghana and did not cover the same period as one finds in this research. Others which took Ghana into account including Kojima et al(2014) and Eberhard et al(2016), IMF(2018) adopted a normative approach as compared to the use of quantitative or estimation procedures used in this research to justify the application of downstream law and policies in answering the research questions in chapters 6, 7 and 8. Other empirical studies that included Ghana (Atems and Hotaling, 2018) and involved the use of quantitative methods as used in this research limited their analysis to power generation and economic development. They used power generation types as independent variables and excluded the characteristics of the power plants, legal, regulatory, fiscal and financial factors in their model. This research also uses power generation as the dependent variable and considers the impact of economic, legal and regulatory issues on electricity security of supply.

A full description of the theoretical basis of the hypotheses tested is included in Chapter 4. Briefly, however, the first hypothesis is based on the positive impact of the size of a generating plant or capacity on the electricity security of supply, as explored by previous authors (Guthrie 2006; Vagliasandi and Besant-Jones 2013; Fiorio and Florio 2013; Gugler et al 2013; Pompei 2013; Di Bella and Grigoli 2017; Spalding- Fecher et al 2017). This hypothesis is stated as:

H_1 The size of a generating plant or capacity is positively related to the level of electricity security of supply in Ghana.

The second hypothesis focuses on the relative impact of the level of electricity prices on electricity security of supply. Previous authors have suggested that the relationship between tariffs and the electricity security of supply is mixed. That is higher tariffs can incentivise generators to increase supply but the extent to which price changes and levels lead to missing money depends on the jurisdiction in question. Therefore, price increases do not necessarily impact positively on electricity security of supply (Swadley and Yücel 2011; Vagliasindi and Basant –Jones 2013; Handerson 2014; Hayland 2016). Hypothesis 2 is stated as:

H_2 The level of electricity prices is not related to electricity security of supply in Ghana.

Hypothesis 3 focuses on regulatory governance and substance which define content, practice and the degree of regulatory credibility and how they impact the level of electricity security of supply. It is based on research that indicates that an effective governance of the power market which has attributes of strong and independent regulators that can enforce and effect constructive policies. Such policies do cover the tariff-setting methodology and guidelines, quality-of-service regulation, regulatory accounting systems, cost pass-through mechanisms, network connection policies, and grid codes (including access rights and standards), and do impact positively on the level of electricity security of supply(Nagayama 2007, 2009; Erdogdu 2011; Vagliasindi and Besant- Jones 2013; Fiorio 2014 Thamae et al 2015; Eberhard et al 2016). Hypothesis 3 is stated as:

H_3 The quality of regulatory substance and governance is positively related to the level of electricity security of supply in Ghana.

Hypothesis 4 focuses on the sustainability practices of power generating firms and how they impact on the electricity security of supply. Empirical studies show that sustainability factor endowment and practices including fossil fuel dependency, climate change, input affordability and the viability of power firms impact positively on the level of electricity security of supply depending on the quantity and quality of domestic input endowments and income levels(Burke 2010; Erdogdu 2014; Larsen et al 2017; Narayan and Doytch 2017).

Hypothesis 4 is therefore stated as:

H_4 The level of sustainability practices of a power generating firm is positively related to the level of electricity security of supply in Ghana.

Hypothesis 5 examines the effect of ownership structures between state ownership and independent power producers (IPPs) on electricity security of supply. The results from the empirical literature show that the relationship between the ownership type and the electricity security of supply is mixed (Fiorio and Fiorio 2013; Gugler et al 2013; Pompei 2013; Ajayi et al 2017). The performance of these power generation entities depended on the country in question, whether the country had the capability to manufacture its own power plants (Yao et al 2018) and the availability and efficiency of domestic capital (Tangeràs 2018) for energy value chain investments. Hypothesis 5 is stated as:

H_5 The ownership of a power generation plant is not related to the level of electricity security of supply in Ghana.

1.9.0 METHODOLOGY

This study employs quantitative data collection and data analysis procedures to deal with different aspects of the research problems. This methodology is complemented with documentation analysis and comparative legal methodology. In keeping with Yao et al (2018), the research evaluates the options for use of the gas resources and power sector contracts involving IPPs and PPAs through the use of documentation analysis. The documentation analysis involves the use of data and reports by reputable institutions on matters relating to the costs of gas production, contracts and their structuring to support the research assertions.

The comparative legal methodology begins by identifying Ghana as the unit of research and with the petroleum and energy regimes identified for their specific roles. This is followed by an analysis of case studies relevant to ensuring that measures taken to secure investor interest for the production of electricity in a sustainable manner to ascertain their functional roles. The comparative empirical observations from Ghana, Argentina, Bolivia, Brazil, China, Columbia, Japan, Ecuador, other EU countries, Mozambique, Nigeria, South Africa, South Korea, Uganda and the UK are used to analyse the various manifestations of legal quality and investor protection with respect to power market design and their implications.

This leads to the adoption of functionalism to define the role of factors that mitigate power generation risks and support transition to a more secure and performing power sector. Having defined the benchmarks through functionalism, the comparative analysis of legal norms, structures and frameworks for possible transplants are used to disapprove or approve the hypotheses established in the thesis.

Out of a population of 13 sources of electricity supply including domestically licensed power firms in Ghana, a sample of 9 is studied because 4 firms are yet to produce or do not satisfy either the minimum of 10 years in existence with power generated for the Ghanaian economy or unavailable data items due to non-disclosure. The share of the excluded firms to total energy supplied by the industry is also insignificant as shown in chapter 2.

The period of study was chosen as it coincided with the period immediately after the commercialisation of gas from Ghanaian and Nigerian supplies. The sample includes four IPPs and five state-controlled firms including the Volta River Authority (VRA) which acts also as the single buyer given the single buyer model in operation on the power market in Ghana. The IPPs are Chinese, American and Turkish firms.

The type of data used in this study is mainly secondary. Data was sourced from the investor relations offices of IPPs in Ghana, the internet, annual Energy Commission reports which covered the period from 2007 to 2016 and the use of library resources for comparative articles on electricity security of supply conceptualisation and measurements.

Electricity security is measured using the actual gigawatt hour generated which is further converted to megawatt hours supplied (IEA 2016). The megawatt hours are then discounted by the nameplate capacity to determine the adjusted capacity factor (which does not take into account the constant 8760 hours (24 hours times 365 days in a year) which affects every generator). This is calculated for each power producer in the sample for the year over the period 2007 to 2016. The outcome is the effective contribution of each generator to the security of supply in terms of availability which also captures the firms' ability to harness their respective endowments. This approach is in keeping with Nicholosi and Fürsch (2009) and Petitet et al (2017) in measuring the contribution of firms to the security of supply. The higher the figure, the more efficient and effective is the plant in contributing towards the security of electricity supply.   A power supplier-level panel regression analysis is then used to assess how the drivers of electricity security impact on electricity security of supply and also to address the research questions above.

Using a panel data analysis, a test of panel data for autocorrelation, heteroskedasticity, and violations of exogeneity, linearity, normality were used to determine the choice of model to ensure the reliability of results and their robustness. For example, the tests for the use of any linear model, fixed or random effects model and generalised method of moments (GMM) estimators were based on the outcomes of the validation and robustness tests using the Hausman, Breusch-Pagan and Hansen Tests.

Following from the outcome a further comparative study of countries' national energy or electricity policies are analysed using a comparative legal methodology to ascertain the gaps in the legal and regulatory framework in Ghana that if corrected can positively support the Ghanaian power market development. The possibility of legal transplants to provide for an effective power market structure is also analysed. The comparative method will cover similarities and differences in the legal framework in the Ghanaian power markets and other countries such as Uganda and Nigeria (capacity short countries) that have been identified to pursue a similar power sector model and are progressing rapidly to reduce capacity shortness. Again the Ghanaian framework is benchmarked against some of the Latin American countries that have transited from capacity shortness to full capacity and EU countries that have excess capacity to determine common grounds that are required in legislative, administrative structures and laws to make changes in Ghana.

1.10.0 SOURCES OF ORIGINALITY

Hart (2009: 24) who cites Philips and Pugh(1994) suggests that originality has been considered to be associated in definition with production using one's own faculties; a result of thought; without copy or imitation; new in style, character, substance or form; authentic, the result of thought; and not been done before. Out of nine identified definitions of what it means to be original, three are applicable to this thesis in the forms of: bringing new evidence to bear on an old issue or problem; creating a new synthesis that has not been done before; and looking at areas that people in the discipline have not looked at before (Thurber and Chang 2011). The originality of this thesis emanates from six integrated routes which provide space for answering the research objectives and questions.

The first explores and develops the principles that govern the sequencing of the process that could ensure full electrification of resource-rich but capacity short economies like Ghana. This adds to the insight that is needed to optimise electricity generation mix in resource –rich developing countries like Ghana.

The second area explored in this research is the focus on gas ownership structures from the wellhead through state owned or state/ private owned pipelines that will guarantee physical gas supply. The options of integrated projects, transfer pricing agreements and throughput agreements have been analysed within the context of the research objectives and modified to reflect the circumstances of resource gas –rich developing countries through contractual structures, horizontal unbundling of the gas sector for the management of future demand and supply of the gas input.

The third is that the research discounts the assumptions underlying gas –fired project financing that the gas exists by either being imported or from domestic sources. This is because in developing countries the gas input cost is critical in determining the cost of power generation and the basis for reward to upstream investors (Thurber et al 2010) which require a critical analysis and regulation to ensure an effective connection between resource availability and its transformation possibilities.

The fourth space is the in-depth role of government in ensuring that electricity price is competitive not for the sake of meeting investor expectations but that the country's entire industrial base stay competitive internationally as electricity remains the major input in the production process. This is reinforced by the fact that these capacity short economies are primary producers and can only improve their international terms of trade through processing or value adding activities which hinge on cheap and the abundant electricity and security of its supply.

The fifth space considers the development of new synthesis within the Ghanaian context that has not been done before. It looks to develop a new regulatory approach that is carried from the electricity market through production to gas and not the vice versa. Such a regulatory structure is focussed on three key objectives. The first involves the need for flexibility in the development of competition within the gas –power value chain to correct any existing market imperfections and to reduce uncertainty for investment. The second involves the minimisation of governmental risk – being exposure through the efficient and free flowing critical liquidation cycle of all transactions within the gas-electricity value chain. The final involves the maximisation of resource rent in matching the domestic use of gas for electricity against alternative uses.

The sixth space involves the development of energy markets with the unique contribution of financial institutions because most of the capacity short economies are bank-based economies. There is the need to reengineer the financing mechanisms to provide the needed liquidity in the downstream segment of the power value-chain. The study links the development of the capital market, the banking and long term financing institutions to the financing of energy projects which the literature is scarce and policy wise is currently not in place (Ngan 2010).

1.11.0 RESEARCH OUTPUT AND THE SIGNIFICANCE OF THE STUDY

The research has produced three significant contributions to the literature. First, it employs the principles underlying the neoclassical new institutional economics in the Ghanaian context by using econometric techniques to provide empirical evidence and analysis to justify the use of energy law and policy measures to tackle the problem of capacity shortness in Ghana. This distinguishes the research from much of the literature on power markets on

Ghana by creating a backward linkage in the governance of the resource value chain for electricity and also to explain the deployment of legal and regulatory measures needed to sustain the electricity sector. The outcome of this research therefore marries the neo institutional economics to the neoclassical new institutional economics paradigm (neoclassical institutionalism) by employing a pluri-legal approach to gain insight into the Ghanaian institutional framework and electricity sector reforms. Secondly, it complements the existing normative analysis and assumptions in much of the literature on electricity security of supply in keeping with Roques and Finon (2017) and Larsen et al (2017) from a global analysis or perspective on electricity security of supply.

Thirdly, the study contributes to knowledge in energy management, energy law and practice in two areas. Firstly, by documenting and advancing incrementally the understanding of current Ghana electricity security structures from the information derived from the data analysis. It again proves a pioneering material to quantitatively analyse the key drivers of electricity security of supply in Ghana. It employs the Blinder –Oaxaca decomposition to analyse the relative performance of hydro and thermal firms in ascertaining whether the current process of managing and planning of the country's electricity generation mix through the energy ladder have some pitfalls and the policies that would be needed to minimise them.

The research also makes two additional findings. The first is to recognise the importance of low-carbonisation of power generation which has not been given attention in Ghana, where solar has huge potential and the use of mini dams over many of the rivers in Ghana are viable options given the performance of Akosombo relative to the smaller dams like Kpong and Bui. Balancing low-carbon power generation with the emerging gas-to-power sector is a strategic issue which needs a proper study for both sustainability and energy justice principles. In keeping with the World Bank (2012) and Prévost and Rivaud (2018) these findings reaffirm the World Bank's perspective of the new institutional economics for any development or reform agenda which the electricity sector is a key component. The study also shows that the issue of decarbonisation of power generation which is based on renewable energy should be given a serious attention in the form of planning and licensing of power producers or potential investors. This requires a proper framework quite different from what pertains in Ghana.

The second is the need to consider three key structures. In the area of gas resource management, fiscal and financial measures need to be well defined. The approach to the management of gas inputs allocation by the current gas aggregator Ghana National Petroleum Corporation (GNPC) through the Ghana Gas Company has to be realigned to promote the long –term development of the gas-to-power sector. The realignment will require that Ghana Gas becomes independent and strengthened resource-wise to become the market aggregator responsible for both demand and supply dynamics.

The research did find a significant difference between the contribution of hydro and thermal production over the period despite the high prices of power due to the increased production of power from thermal sources. The findings therefore support the urgent need to scale up the implementation of legal, financial and fiscal, safety and regulatory measures to incentivise the IPPs to protect their franchise value (Massie et al 2015). The findings further suggest that these measures should be targeted at the renewable sources of energy which have not been harnessed fully and also on critical matters that promote their availability such as water basin management, including reforestation. In the case of solar the potential is enormous for both employment, industrialisation and for exports. Such regulatory measures will minimise distortions in investor risk-taking incentives and result in sustainable electricity sector stability in Ghana.

1.12.0 LIMITATIONS OF THE STUDY

This work is limited to the regulation and firm-level risk management of the Ghanaian power segment from a top-down approach. Although it discusses the regulatory design dimensions of electricity security definition, measurement, monitoring and controlling, it does not consider the tactical application of risk measures at firms' operational level. Two interlocking tensions were recognised.

First, the study does not take into account the possible impact of other electricity generation sources such as biomass and wind power generation firms operating in Ghana. This problem is limited to capacity short but resource gas – rich economies in terms of having commercial and economic quantities of gas resources. It is also limited to countries where room for nuclear energy is not economical and dangerous due to the lack of infrastructure and human capacity to manage and secure the facility. Again, it is limited to where even full exploitation of hydropower potential has not been fully harnessed due to lags in establishing hydro projects with its attendant climatic and hydrology risks as compared to deploying a combined-cycle gas turbine (CCGT) technology. The other alternative sources of energy also need large scale facility development and their current total capacity cannot provide or satisfy the energy intensity required by their industrial activities for sustainable economic development in the short term. Balancing decarbonised electricity sources with gas –to-electricity provides the most immediate, medium and long- term economic and sustainable means of ensuring the electricity security of supply in Ghana.

The second limitation is the potential application of classic project-finance models for projects in developing countries that are resource gas rich and undergoing a transition from capacity deficiency to increasing capacity build-up leading to a hybrid state -dominated power market with a privately financed firms operating in the market.

Three interlocking tensions need to be recognised. The first is the commitment of the gas producer to electricity input supply if an alternative use of the gas produced provides a higher return. The second is circumstances to make the private sector an attractive option and the recognition that it is not always so.

The third is whether the expected gas –to-power projects exceed the risk-bearing capacity of the host governments regardless of the rings of containments arrayed around them in the forms of sovereign guarantees, airtight contracts, multi-lateral and bilateral partners (as well as lenders and insurers) and offshore arbitration designed to circumvent difficulties with local courts and improve the ultimate enforceability of contract terms. Capacity expansion through the private sector such as the International Power Producers (IPPs) programme has its limitation as the rapidly expanding generation capacity, the greater the exposure of the host government or host consumers will be. An alternative suggestion has been the sale of VRA thermal assets which conflicts with sovereignty, strategic control and the future use of electricity in Ghana.

The University of Dundee Ethics policy has strictly been complied with. In all verbal communications with the representatives they were carried out in a way that ensures confidentiality and no ethical compromise. There has been no particular ethical issue relating to the research since most of the secondary data required are in the public domain and no reference to a particular representative has been made by name in this thesis. Again, confidentiality clauses being applied by the respective institutions will not be envisaged.

1.13.0 STRUCTURE OF THE THESIS

This thesis is organised into nine chapters beginning with Chapter 1. This chapter provides an introduction to the thesis and covers the main reasons why the research is worth doing. This chapter therefore covers the background to the study, motivation for the research and its objectives, research questions, an overview of the contribution of the research and limitations to the research.

Chapter 2 discusses the Ghanaian environment, risk and regulatory regime with respect to the power market. It provides the facts relating to the case study and the effect of the post 2008 energy sector deregulation. It critically examines the literature on the Ghana regulatory regime and the nature of power market risk taking and activities. The gaps in the literature to support the purpose of the research are examined to reaffirm the need for this research.

Chapter 3 sets out to analyse the literature on the research on power market and electricity management practices. Specifically, it examines the main planks of power sector regulations that include entry, exit and decommissioning, supervision and monitoring, accounting and governance. It further provides a review of the theoretical and empirical literature on how these strands of literature emanating from these planks relate to electricity security of supply measured by actual power produced as a proxy. The literature is further critiqued to identify gaps in the literature to support current and future research.

Chapter 4 provides the research philosophy and discusses the theoretical perspectives of the conceptual framework which is framed on the gaps identified in the literature in chapters 2 and 3. The framework is then used to develop the research hypotheses that are examined in Chapter 7 to answer the research questions and justify the choice of the covariates in the research model.

Chapter 5 explains the methodology used in the study, which includes the selection of the sample and the data collection method. This chapter also discusses the variables used to measure, conceptualise and operationalise the hypotheses, and includes a discussion of the statistical techniques employed to analyse the data. The chapter is divided into two. The first part of the chapter presents the methods to be used to undertake the descriptive statistics of the security of electricity supply, supply risk factors and their profile.

The second part discusses the dependent (electricity security of supply) and independent variables namely: plant size; financial efficiency, endowment or sustainability characteristics, ownership (government ownership or IPP) and regulatory reforms. These variables are defined and the bases of their measurements are further explained. The theoretical and empirical sources of how the variables are measured are further discussed. Since linear regression models will be used to assess the panel data, the OLS assumptions become important to identify violations of these assumptions and therefore provide the basis for the choice of appropriate methods to be used in Chapter 7. The underlying OLS assumptions of normality, homoskedasticity, linearity, no multicollinearity and autocorrelation, are defined and the required diagnostic tests carried out. These tests are provided as an appendix to this thesis. The theoretical framework for the tests of panel data using the Hausman and Breusch-Pagan tests which are used to support the choice of estimation techniques involving static panel data are also discussed.

Chapter 6 discusses the results of the univariate analysis of the data. Here descriptive statistics compare the production of thermal electricity to hydro among the sample power producers. Again ownership considerations based on the contractual structure and governance between state-owned and IPPs are analysed. Correlation analyses and an analysis of variance of thermal and hydro firms ; state-owned and IPPs are compared to answer the first research question on the relative changes in the structure , that is the generation and investment structure on the electricity security of supply. The policy implications of the findings and recommendations which include the need to improve the regulation on power production, transmission and distribution are also discussed.

Chapter 7 discusses the empirical results. The empirical results based on the pooled OLS, fixed effects, random effects, and GMM models are the first to be discussed, followed by an analysis of the results based on the key research findings. The robustness or sensitivity of the results to the potential presence of autocorrelation in the panel data will be addressed by using the GMM HAC (heteroskedasticity and autocorrelation) option. The policy implications and suggested recommendations of the key research findings are also discussed to answer the second research question.

Chapter 8 discusses normatively how the capacity shortness can be eliminated to answer the third research question. It employs the documentation analysis and comparative legal methodology to analyse the sequencing of the power market development in Ghana. It critiques the sequencing of the reforms and discusses issues that can impact on the full electrification of Ghana.

It discusses the issues from the legal, financial and fiscal aspect of project financing which captures the processes that will physically transform the various value-chain activities into real capacity generation systems. It discusses the various components as projects and the general and specifics risks that have to be managed to achieve the desired results. It sets the discussions from an angle where financing is coming from international investors and concludes with the discussion of domestic capital market development to support the future development of the electricity sector or power markets in Ghana.

Chapter 9 presents the conclusions of the thesis. It discusses the summary of the research key findings, contribution of the research to the power industry management and practice and academia. It points out the main limitations of the study as well as the potential avenues for future research and improvement.

CHAPTER 2

GHANAIAN POWER MARKET ENVIRONMENT, RISK AND REGULATORY REGIME

2.1 INTRODUCTION

This chapter discusses the environment in which power firms are regulated in Ghana. It critically examines the literature on the Ghanaian power market regulatory structures and discusses further how they impact on electricity security of supply.

Historically, the structure of Ghana's economy has been dominated by the primary sector, characterised by the production and export of primary products such as cocoa, gold, bauxite, foodstuff and timber (IMF 2014). Ghana's economy has shifted from an agricultural producing economy in the1980s to a service economy. Commerce, transport and other allied services now contribute more to the Gross Domestic Product (GDP)(IMF 2014).

An analysis of the components of the country's GDP shows that the services sector accounts for over 52% of the GDP and employs about 47% of the active labour force. The literature on electricity demand and intensity show a positive relationship between economic transformation and electricity demand (Gyamfi et al 2015). Osman et al (2016) extend this argument and provide empirical evidence that there is a bi-dimensional causality between economic growth and electricity consumption in the Gulf Cooperation Council (GCC) countries using annual data from 1975 to 2012.

Table 2.1 below shows the sectoral output in 2000, 2010 and 2016 in relation to the gross domestic product (GDP).

Table 2.1 Sectoral Output in Ghana

	Year and percentage contribution to GDP		
Key Sectors of the Economy	2000	2010	2016
Agriculture	39	31	20
Industry	28	20	28
Services	32	49	52
	Source: The World Bank Country Profile 2017		

Ghana mainly exports non-processed oil and non-oil commodities. Soft commodity exports notably cocoa, still forms the anchor of its foreign exchange earnings, followed by remittances and hard commodity exports like gold and other minerals(IMF 2013a).

Post 1997 saw further legal reforms that allowed for increased liberalisation of the energy sector, leading to an influx of IPPs (Eberhard et al. 2016). The influx of the new IPPs has enhanced competition in the generation sector, while the VRA remains the single buyer. The recent Compact II Agreement will see private investor participation in the downstream distribution of power with the Electricity Company of Ghana. Data from the World Development Index (WDI

2015) show that real per capita income in Ghana had increased from USD 575.0 in 1980 to USD 752 by 2013.

On the economic front, Ghana's qualification for debt relief under the Highly Indebted Poor Countries (HIPC) initiative and the accompanying fiscal and monetary policy stance resulted in a significant reduction of the debt burden by the end of 2008(IMF 2014).

This situation has changed rapidly since the end of 2008. In 2008, Ghana's total public debt stood at GH¢10.14 billion (33.6% of GDP), equivalent to $7.57 billion (IMF 2011). In the last five years, however, the stock of public debt has increased to GH¢49.7 billion (57.4% of GDP), equivalent to about $20.12 billion at the end of 2013 (IMF 2014a). At the same time, there has been a dramatic increase in central bank financing of government recently (i.e. equivalent to the printing of money). Figures from the IMF show that net domestic financing of government exceeds the Bank of Ghana's own target (IMF 2015).

However by the end of 2016, the total energy sector reached an estimated 2.4 billion dollars, over 6% of Ghana's GDP (1MF 2017a). An earlier audit by Ernst and Young (EY) had put the energy sector's debt at 13% of Ghana's GDP at end-June 2016. It is reported that 50% of the state –owned energy (SOE) firms' debts are owed to banks, 30% to suppliers, and 17% represent intersectoral debts (IMF 2017b). Poor quality of financial data and missing data undermined debt validation (IMF 2017 b). The Volta River Authority (VRA) and Electricity Company of Ghana face a viability issue. For VRA, an estimated 32% upward tariff revision would be needed to breakeven (IMF 2017 b). This has been attributed to the continued accumulation of losses and lack of discipline in ensuring the timely payments of bills (IMF 2017a). For ECG, while the end-2015 tariff increase has helped (as shown by the profit posted in 2016) its receivables have continued to accumulate. The inability to collect billed amounts and the subsequent accumulation of payables has cascading effects across the utility value chain, especially on VRA.

Thus, the sector's net payables have increased again since 2014, to 2.3% of GDP at end-June 2016 (IMF 2017b). More importantly, other energy companies, including GRIDCO (the transmission company), Ghana Gas, the independent power producers (IPPs) depend on VRA's financial viability (IMF 2017b). The companies are the Electricity Company of Ghana (ECG), the Volta River Authority (VRA), GRIDCO (the electricity transmission company), Ghana Gas (GNGC), and the Tema Oil Refinery (TOR).

To address concerns raised by the audit about the financial viability of the state-owned enterprises (SOEs), the government has decided to take a three-pronged approach: (i) to restructure the SOE debt; (ii) to strengthen the payment discipline; and (iii) to introduce private sector participation in distribution, by concessioning the ECG under the Second Compact with the Millennium Challenge Corporation (MCC)(IMF 2017b).

2.2 ECONOMIC ENVIRONMENT AND ITS IMPACT ON REGULATION AND ELECTRICITY SECURITY OF SUPPLY

Persistent deviations from the settlement of debts dates by the Volta River Authority (VRA) have created the financial risks for suppliers or generators of inputs and power in Ghana. In addition, it has created an offtaker risk for current and potential IPPs. This has led to increases in the cost of power and power failures due to the West African Gas Pipeline (WAGP) and Nigeria Gas for example, cutting off gas supplies to Ghana due to power debts in 2015 and 2016. The financial viability of the energy sector remains a key issue. The Energy Sector Levy Act (ESLA) enacted in 2016 is to among others address the legacy debt of the oil refinery and support the payment of power utility bills. These levies serve as collateral and funding for debt restructuring with banks. However, continued inefficiencies and poor collection have taken a heavy toll on energy companies' balance sheets, standing in the way of investment and capacity expansion, and creating contingent liabilities for the government. The government is currently considering issuing an energy bond (GHC 10 billion, or about 5% of GDP) backed by ESLA revenues to address legacy liabilities and strengthen the sector's financial position(IMF 2017 : 18-19)

The establishment of the Public Utilities Regulatory Commission (PURC) in 1997 has also been affected by political influences on pricing and distribution charges. Under such an environment, political objectives can get in the way of effective regulatory and its related administrative policy and hence weakening the credibility of the government in restraining VRA from defaulting on its debts and obligations. Indeed, a policy commitment that is consistently breached cannot be credible.

The economic effects included the rapid deterioration of the domestic currency, the cedi. This had been against the backdrop of rigid tariff adjustments which should have a passthrough effect of such currency depreciation on the prices of goods and services (IMF 2014a). Studies on energy firms in emerging and developing markets show that the depreciation of domestic currency can have a detrimental effect on power market performance and the security of supply. Vagliasindi (2013) found that local currency depreciation increases energy firms' fragility in Asia and Latin America while Eberhard (2011) who examined 12 Sub-Saharan countries including Ghana between1995 and 2010 found similar evidence for the region. They stress that the sustainability of the power sector in a liberalised and competitive economy is contingent on government pursuing sound macroeconomic policies and enhancing the effectiveness of institutions to allow the power sector to thrive.

The current situation has implications for power sector regulation in Ghana. This strengthens the argument for proper tariff setting, the monitoring of utility firms and the independence of the regulator. Continued inefficiencies in the downstream power sector shows that the reported tariff per kilowatt hour is the full amount borne by the Ghanaian consumer. The ESLA imposes an extra burden creating the additional issue of affordability. Again it also calls for a shift in the allocation of power to users and physical planning of the Ghanaian landscape to allow for an effective distribution of power to those who are willing to pay given the nature of the distribution lines and settlements in Ghana.

The independence of the regulator will demand a proper and an efficient management of the utility firms to minimise the current low levels of administered tariff setting and cross areas with government and other state-owned enterprises (IMF and IDA 2016 :5). In short the fiscal measures are not adequate unless there is a proper understanding of how the power value chain is managed.

2.3 ENERGY DEMAND ANALYSIS IN GHANA

Energy demand in capacity short economies like Ghana has three components. The first is the market demand, which is associated with the different levels of economic growth, structural change, and population growth. The second is the suppressed demand, which is created by the frequent blackouts and the ubiquitous power rationing. The third is the social demand, which is based on the political targets for increased access to electricity (Eberhard et al. 2011). In most low-income countries, notional demand exceeds supply. Notional demand refers to the aggregate quantity of goods and services that would be demanded if all markets were in equilibrium. The difference between the two is suppressed demand, which arises for two primary reasons. First, people who are on a waiting list to get connected are not captured in baseline demand estimates. Second, frequent blackouts and brownouts reduce consumption but not notional demand. Ultimately, suppressed demand will immediately absorb a certain amount of new production even before taking account of income growth or structural economic changes.

The rationale for demand analysis is to understand the structure of demand for power, the level of power needed for development and economic transformation and the implications of time and opportunity costs in managing or undertaking to eliminate the capacity shortness. The comparative kilo watt hour per head in electricity consumption in some developed countries and that of Ghana in 2014 is presented in Table 2.2 below.

Table 2.2 Comparative Electric Power Consumption (per capita kWh)

	Country	**per capita kWh in 2014**
1	China	3,924
2	Germany	7,035
3	South Africa	4,229
4	UK	5,130
5	USA	12, 987
6	Ghana	355
Source: The World Bank (2017) Data on Electric power consumption (kWh per capita).		

Ghana requires a minimum of 500 kWh per capita to industrialise. This is equivalent to a minimum installed capacity of 12, 500 MW (The Government of Ghana -The Concept Paper 2012:4). With the current market demand growth of 13.9 per cent (GRIDCO 2015) and 460.2 kWh per capita in 2016(Ghana

Energy Commission Statistics 2017), Ghana needs to manage its demand and usage of power for the needed industrialisation drive. The estimated annual growth rate in energy demand exceeds the growth in supply due not only to urbanisation and population growth (Owusu Appiah 2018), but the policy of government to transform Ghana into an industrial state.

Managing demand has been defined as a systematic utility and government activities to change the amount and/ or timing of customer use for the overall benefit of the society (Bhattacharyya 2009a). Such measures encompass various activities such as load management, energy conservation, fuel substitution and load building.

Load management options at the disposal of power managers, are used to alter the load shapes so that the demand during the peak period is reduced (thereby reduce the demand for investment in new peaking capacities) and the facilities are better utilised at other times (which reduces the costs of production). Load management options include peak clipping, valley filling, load shifting, electrification, energy conservation and flexible load shape (Bhattacharyya 2009a).

The complexity of capacity short economies is the role of energy politics which encourages load building in an attempt to conserve the environment and shift demand from wood to electricity. In developing economies electrification which enhances energy access is not integrated with strategic investment sustainability but to reduce energy poverty to rural areas where there is little economic activity at an additional cost through subsidisation. The end result is the use of an extreme form of direct load control such as load shedding where utility supply is cut for considerable hours or days to manage the demand. The share of political voice in the pricing of utilities makes the use of indirect load control through pricing difficult because utility companies segment the consumers based on purpose and not the ability to pay and the utility maximisation concept. Even with the use of prepaid meters to promote a commitment to product or service valuation, illegal connections contribute significantly to making it ineffective. Low investments into loss control and reduction systems in a poor transmission infrastructural environment are equally as critical as the production itself.

The long term management of an effective demand for electricity involves the creation of a market through government efforts and assurance to investors through contractual means. Primarily undergoing liberalisation but not creating a market leaves a government in limbo. It is not expedient to ask investors to take a market risk where there is no market in which to mitigate that risk (Dow 2010). It simply makes no conceptual sense. It is also inexpedient for a government to promote a liberalisation scheme, and then proceed to assume risks under contract with the new participants. The energy strategy has to show how the government will address this problem. This is a serious problem in many countries which liberalise in an effort to attract investment (Dow 2010).

PPAs are also not entirely incompatible with the concept of liberalisation. Markets sell commodities by many different methods. One of these is long term contracts. There is nothing conceptually wrong with having long term contracts in a market and indeed the market may demand long term contracts to underpin investment. It is obvious that exactly the same problem exists in the gas industry. The major risk is the volume risk – how to sell the capacity of the power plant or the gas import/input terminal. If there is no market, the investor is not able to mitigate the risk other than by passing it to government. That then puts the cost straight back to the government's balance sheet – a cost that the government ultimately hoped that liberalisation would remove (Dow 2010).

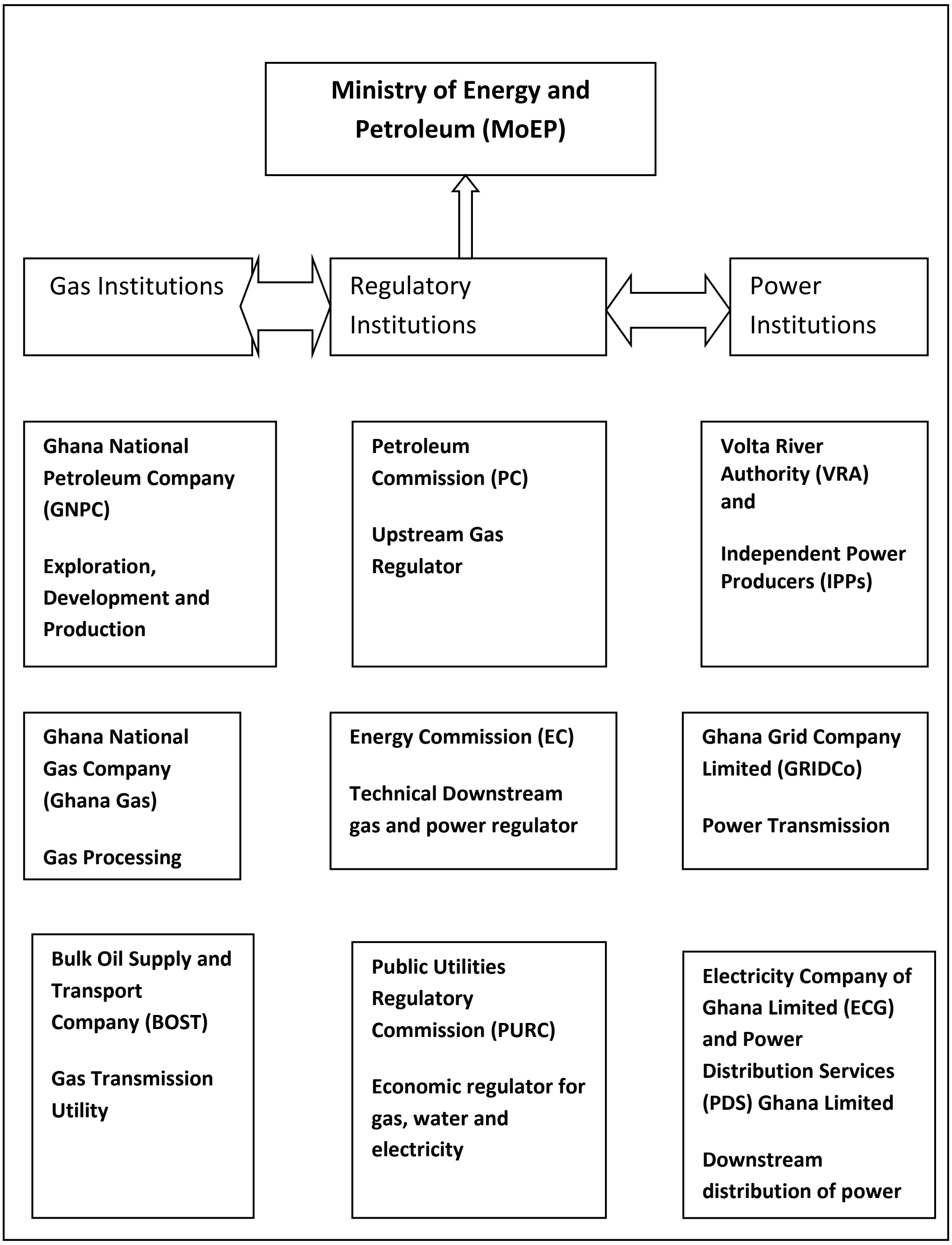
Guarantees are inevitably demanded by lenders where the buyer does not have the credit rating to pay for power. In the absence of a guarantee, the PPA might find itself dependent upon an actual or potentially insolvent company in many cases. Lenders will not take the risk. The guarantee is required to promote investment. There is an upside for government in that complying with the terms of a guarantee will create a favourable track record in the eyes of lenders and sponsors. There is also an upside in that it creates a powerful incentive to rethink the subsidy on the electricity price, which in turn then makes the creation of a functional liberalised market more straightforward. If there is no subsidy reform, guarantees have the potential to prove expensive for government. The simple way to limit exposure under the guarantee is to ensure the supplier (buyer) has the funds to pay for power under the PPA by himself without call on the guarantee. That implies consumer price reform. As noted above, the World Bank in particular is in favour of the abolition of subsidies; it should also be noted that the rapid removal of subsidies can cause severe problems for consumers. It is of course possible to subsidies consumers by other (indirect) means (Dow 2010).

2.4 THE STRUCTURE OF GHANA'S POWER SYSTEM

At the apex of the energy sector in Ghana is the Ministry of Energy and Petroleum (MoEP) established in 2015 to provide the energy policy of the government. Under the Ministry of Energy are institutions established to ensure the efficient management of energy policy and strategies of the government. At the centre is the regulatory institutions created to deal with the means to generate, transmit and distribute power. The gas institutions have been established to ensure efficient input supply. At the helm of the structure is the Ghana National Petroleum Corporation (GNPC) that is the national oil company (NOC) responsible for the exploration and development of petroleum (oil and gas) resources in Ghana. At the same time it is given the responsibility as the gas aggregator for both demand and supply. The Ghana Gas Company is under GNPC and is responsible for the processing of gas for offtakers. The Bulk oil, Storage and Transport company (BOST) is the pipeline company responsible for the storage and transmission of oil and gas to various users. The generation of power is subject to the oversight of two institutions. The Energy Commission licences power firms subject to their satisfaction of environmental protection requirements and proper development plans.

Figure 2.1 illustrates the structure of the power system capturing the gas-to-power system.

Figure 2.1: The Institutional Structure of the Ghanaian Gas-to Power System



Source: Author's Illustration: Adapted from Pondiren and Fritsch (2016) and modified by the Author.

The regulation of the market is the responsibility of the Public Utilities and Regulatory Commission (PURC). The players include power producers, state-owned and IPPs, the transmission company, the GRIDCO which is a monopolist and distributors; the dominant being the Electricity Company of Ghana (ECG) and now Power Distribution Services(PDS) Ghana Limited . The Northern Energy Distribution Company is a subsidiary of the VRA and accounts for less than 10 per cent of the entire power distributed in Ghana.

2.5 THE LEGAL AND REGULATORY FRAMEWORK

Article 14 of the Model Petroleum Agreement (2000) provides the legal framework for the development of gas resources in Ghana. State ownership of petroleum resources is premised on the principle of national sovereignty. In the context of petroleum resources, this means that the State has exclusive dominion and ownership over the geological formations within its national borders, including any natural resources found within such strata. State sovereignty over petroleum resources is well-recognised in international law, and has been addressed in various United Nations Resolutions (UN General Assembly Resolution 626 (1952); UN General Assembly Resolution 1314 (1958); UN General Assembly Resolution 1803 (1962); UN Charter of Economic Rights and Duties of States (1974); and UN Charter of Economic Rights and Duties of States, UNGA Resolution 3281 (1975)).

The right of people to use and exploit their natural wealth and resources is inherent in their sovereignty. The exploration, development and disposition of such resources, as well as the import of the foreign capital required should be in conformity with the rules and conditions desirable with the authorisation, restriction or prohibition of such activities the people and nations freely consider to be necessary. The above resolutions are an important indication of international consensus and are evidence of customary international law despite their legal status being the subject of debate as to whether they are legally binding. Article 56 of the 1982 United Nations Convention on the Law of the Sea (UNCLOS) allows a state to establish a 200 nautical mile exclusive economic zone (EEZ) from which the territorial sea is measured. An EEZ is established 'for the purpose of exploiting, conserving and managing natural resources, whether living or non-living, of the waters superjacent to the seabed and of the seabed and its sub-soil with regard to other activities for economic exploitation and the exploration of the zone, such as the production of energy from the water, currents and wind '. On the basis of the International Court of Justice, should any mineral resources (e.g. petroleum) be discovered on the continental shelf, the parties shall reach agreement on the principle that each contracting party is entitled to the mineral resources located on its continental shelf. Under Article 77, Coastal states have an exclusive right to exploit natural resources on their continental shelf. The continental shelf is not to exceed the greater of 350 nautical miles from baselines, or more than 100 nautical miles from the 2500 meter depth isobath.

Sovereignty is expressed through the enactment of domestic laws that vest the ownership of petroleum resources in the state. Claims of ownership, and hence the authority to control the exploration and development of petroleum resources, is contained either in national constitutions or specific petroleum laws (Duval et al 2009).

State ownership of petroleum resources is significant for two reasons. First, it determines which nation has the right to the economic benefit of those resources. Second, it determines which nation has the authority to grant exclusive rights for the exploration and development of those resources. This point is fundamental to providing security of title to petroleum once it is produced and ready to be marketed. Regardless of the extent to which the State decides to intervene in the sector, the natural monopoly characteristics of access to facilities for processing and transportation mean that some form of governmental oversight is necessary particularly in capacity short economies.

The Model Petroleum Agreement (2000) also takes into account issues in relation to gas field development, environmental issues and the actual exploitation of gas proven reserves. Section 14.5 gives the state oil company the Ghana National Petroleum Company (GNPC) the right to offtake any associated gas at the flange of the gas-oil separator at its sole risk for its own use, if the contractor considers that product in processing and utilisation of associated gas from any development and petroleum area to be uneconomic.

The system for the allocation of natural gas among parties are as follows: royalties shall be at the rate of five per cent(5%) of the annual gas production of natural gas as compared with twelve and half (12.5%) in the case oil as an incentive to enhance the viability of gas projects in Ghana. Section 10.2 deals with the after –tax inflation-adjusted rate of return (ROR) which is defined by considering all revenues received in a month less monthly taxes and petroleum costs or gas costs. For the purpose of ROR computation, petroleum or gas costs shall not include any amounts in respect of interest on loans obtained for the purpose of carrying out petroleum operations (Model Petroleum Agreement 2000).

2.5.0.1 Fiscal Stability and Legal Stabilisation Incentives

The 1992 Constitution of Ghana guarantees all investors against expropriation without the payment of fair and adequate compensation. Section 2(1) of the Energy Commission Amendment Act (2016) Act 933 requires that the commission should promote local content, local participation in electricity supply, transmission and distribution. To promote foreign and local joint participation, the Ghana Investment Promotion Centre Act, 2013 (GIPC Act No. 865 of 2013) law provides locational incentives through the establishment of power firms under the aegis of the Free Zones Act, 1995(Act 504) with the following benefits:

- 100% exemption from payment of direct and indirect duties and levies on all imports for production from free zones;
- 100% exemption from payment of income tax on profits for ten years and shall not exceed 8% thereafter;
- total exemption from payment of withholding taxes from dividends arising out of free zone investments;
- relief from double taxation for foreign investors and employees;
- no import licensing requirements;
- minimal customs formalities;
- 100% ownership of shares by any investor – foreign or national in a free zone enterprise is allowed;

- there are no conditions or restrictions on the repatriation of dividends or net profit; payments for foreign loan servicing; payments of fees and charges for technology transfer agreements; and the remittance of proceeds from the sale of any interest in a free zone investment.

2.5.1 Licensing and Permitting

A Licensing Manual for the Natural Gas Supply Industry was developed by the Energy Commission in 2008 to serve as a guide for prospective natural gas service providers with regard to licensing requirements as well as assisting in ensuring compliance with codes and standards governing quality, health and safety in the industry as stipulated in the Energy Commission Act, 1997 (Act 541). The reviewed Licensing Manual for Natural Gas Supply Industry (2013) serves the same purpose and also aims to facilitate the accelerated development of the natural gas industry (Energy Commission of Ghana 2017).

BOST has been formally licensed as the Natural Gas Transmission Utility to operate the Natural Gas Interconnected Transmission System (NGITS) (Energy Commission of Ghana 2017). The Energy Commission has thus further issued the following licenses to players in the Natural Gas industry. In 2013 a Provisional Liquefied Natural Gas (LNG) Facility License was also issued to Quantum Power Ghana Gas Limited for an LNG facility to be sited at Tema in the Greater Accra Region. Quantum power was granted a Siting Permit for the LNG facility after a presentation and site appraisal from the Energy Commission Siting Committee. Construction permit has not been issued yet. Earlier in 2012 a Provisional Wholesale Supply License was issued to Rotan Gas Limited for an LNG facility to be sited at Aboadze in the Western Region. The Rotan facility is to feed into a 660 MW power barge owned by Rotan. A provisional LNG facility license was issued to Newstar Terminals at Atuabo. The company intends to regasify LNG supplied by Sage Petroleum. No further licence has been issued since (Energy Commission of Ghana 2017).

2.5.2 Codes of Practices and Regulations

Since the natural gas industry is still new in Ghana and like any other energy infrastructure, it is important that developers satisfy some basic requirements and comply with established regulation before the construction of facilities takes place. It is in this respect that the Energy Commission has developed the Natural Gas Pipeline Safety Regulation with the adopted Ghanaian Standards and which has been approved by Parliament in 2012(Energy Commission of Ghana 2017).

A Natural Gas Transmission Access Code to establish conditions for Natural Gas Service Providers to have fair, transparent and safe access to the Natural Gas Transmission Network in Ghana has also been developed in accordance with Sections 24, 27 and 28 of the Energy Commission Act, 1997 (Act 541)(Energy Commission of Ghana 2017). The Commission however is still developing an Occupational Health and Safety Regulation with the adopted Ghanaian standards (Energy Commission of Ghana 2017).

2.5.3 Renewable Energy Regulation

The development, management, utilisation, sustainability and adequate supply of renewable energy for the generation of heat and power in Ghana are regulated by the Renewable Energy Act of 2011, Act 832. Section 2 of Act 832, defines renewable energy as a means of energy obtained from non-depleting sources including: wind, solar, hydro, biomass, bio-fuel, landfill gas, sewage gas, geothermal energy, ocean energy among others. Section 25 of Act 832, establishes four key mechanisms. The first is a feed-in –tariff scheme for the purpose of guaranteeing the sale of electricity generated from renewable energy sources. The second is renewable energy purchase obligation by which distribution utilities are obliged to procure a specified percentage of total electricity purchase from renewable energy. The third mechanism is the connection to transmission and distribution systems where the transmission and distribution system operators are obliged to provide connection services for electricity from renewable energy. The final mechanism is the renewable energy fund which offers financial support for activities for the promotion, development and utilisation of renewable energy, such as financial incentives, feed-in-tariffs, capital subsidies, production-based subsidies and equity participation (Hagan 2015).

Ahiataku –Togobo (2016) shows that four additional mechanisms have been instituted in the course of implementing the earlier four mechanisms. They include the licensing regime for commercial renewable energy service providers among others to ensure transparency of operation in the renewable energy industry. The second is the off-grid electrification regime to promote mini-grid and stand-alone renewable energy systems for remote off-grid locations. The next is the woodfuels and biofuels regime to promote the efficient production and utilisation of woodfuels and biofuels for internal use and export where applicable. There is an ongoing research and development regime which aims to promote innovative renewable energy options including biofuels for transport and export (where necessary). Finally is the establishment of the Renewable Energy Authority to own, implement and manage renewable energy assets on behalf of the state, particularly, for off grid electrification.

2.5.3.1 Critique of the Renewal Energy Regulation Implementation in Ghana

In line with the provisions of the Renewable Energy Act 832, the Ministry of Energy and Petroleum established the Renewable and Alternative Energy Directorate (RAED), which has the legal mandate to coordinate all efforts and manage the development and promotion of renewable energy technologies in Ghana. More specifically, the RAED oversees: i) the implementation of renewable energy initiatives; ii) executes renewable energy programs and projects initiated by the State, or in which the State has an interest; and iii) manages the renewable energy sub-sector assets on behalf of the State until such a time when the Renewable Energy Authority (specified by the Renewable Law) is established (Hagan 2015). Again the feed-in-tariff scheme has been extended to cover three phases. The first renewable energy feed-in –tariff scheme gazette was introduced in October 2013 was limited to10 years and no provision for investment in energy storage for grid stabilization for variable renewable energy (RE) (wind and Solar) was made. The summary is presented in Table 2.3 below.

Table 2.3 Summary of RE-FIT Gazette from Oct 2013 – August 2016 in Ghana

Type of Technology	Phase 1(1 -10 years) Guaranteed FIT	Phase 2 (11 – 20 years) Indicative Range		20 years Guaranteed FIT
	US Cents per kWh	Minimum FIT (US cents/kWh)	Maximum FIT (US cents/ kWh)	US cents / kWh
Wind	16.5541	11.590	13.2400	14.2575
Solar PV	15.1029	10.5700	12.0800	13.0076
Hydro≤ 10 MW	13.4114	9.3900	10.7300	11.5508
Hydro(>10 MW and ≤ 100 MW	14.3204	10.0200	11.4600	12.3336
Tidal Wave (Ocean Wave)	13.4114	9.3900	10.7300	11.5508
Run off River	13.4114	9.3900	10.7300	11.5508
Biomass	17.5100	12.2600	14.0100	15.0807
Biomass (Enhanced Technology)	18.4565	12.9200	14.7700	15.8959
Biomass(Plantation as Feed Stock)	19.7865	13.8500	15.8300	17.0414
Landfill Gas	17.5100	12.2600	14.0100	15.0807
Sewage Gas	17.5100	12.2600	14.0100	15.0807
Geoplutonic(Geothermal)	11.8000	8.2600	9.4400	10.1600
Gazette in Ghana Cedis at GHS 3.9498/USD (July 31 2016 Interbank Exchange rate) PURC				

Source: Ministry of Power –Renewable and Alternative Energy Department (2016). Five Years of Implementing the Renewable Energy Law Act 832 – Successes and Challenges.

The second renewable energy feed -in- tariff gazette was introduced in October 2014 which extends the period between 11 to 20 years range. It maintains the 10years with capacity limit for variable RE (wind and Solar) and makes provision for grid stabilisation and storage. The third renewable energy feed –in-tariff gazette was introduced in August 2016. It makes provision for 10 and 20 years and capacity limit subject to grid impact studies.

The feed-in-tariffs, although they may be changed in future, they serve as a mechanism to incentivise investments in the renewable source of energy generation in Ghana. The renewable energy targets by the Ministry of Power in 2018 as shown in Table 2.4 below seem ambitious if the implementation processes are not properly synchronised and accelerated.

The reasons are that except for the National Electricity Grid Code (2009) for renewable energy, renewable energy feed-in tariffs and the import tax exemption for solar PV system that are being implemented, the renewable energy purchase obligation, the renewable energy power purchase agreement template and the framework for the establishment of renewable energy fund are still yet to be implemented. The absence of these supporting mechanisms affect the degree of resource availability, and more importantly the market and its governance system for the proper working of the power sector and therefore towards achieving a sustainable electricity security of supply.

Table 2.4 Renewable Energy Targets 2015 – 2030 in Mega Watts (MWh) in Ghana

RE- Technology	2015	2020	2025	2030
Large Hydro	1,404.0	1,404.0	1,404.0	1,404.0
Small Hydro	-	-	315.0	608.0
Waste-to-energy	-	10.0	10.0	10.0
Biomass	-	97.0	305.0	555.0
Landfill Gas to Energy (LFGTE)	-	0.2	0.2	0.2
Biogas	-	-	30.0	30.0
Wave	-	15.0	25.0	114.8
Wind	-	150.0	400.0	650.0
Solar PV	22.5	243.0	615.0	1,072.5
Total (incl. L. Hydro)	1,426.5	1,919.1	3,104.1	4,444.4
Total (exc. L. Hydro)	22.5	515.1	1,700.1	3,040.4

Source: Ministry of Power –Renewable and Alternative Energy Department (2018) The Future of Renewable Energy in Ghana: The Master plan.

2.5.4 Power Markets

The revised Licensing Manual 2013 for service providers in the electricity supply industry set the requirements and guidelines for entities desiring to acquire licenses to operate in the electricity supply industry. Under the licensing framework, provisional and full licenses have been issued to entities engaged in the various segments of electricity supply. Besides adding generating capacity to the existing capacity and enhancing service delivery to customers, the licensing regime enhances the Commission's authority to hold the licensees to the terms and conditions stipulated in the license (Energy Commission of Ghana 2017).

Many licenses and permits have been issued by the Commission. In 2015, construction permit was issued to Amandi Energy for the construction of 203 MW Combined Cycle at Aboadze in the Western Region. The Company had earlier been issued with a siting permit during the third quarter of 2013. Construction works on the 300 MW Cenpower Generation Plant is on-going but is not expected to be completed this year (Energy Commission of Ghana 2017).

The following companies were also granted construction permits: Sunon Asorgli Power (Ghana Ltd) expansion of 360 MW combined cycle at Kpone in the Greater Accra Region; Marinus Energy Limited 80 MW Simple Cycle at Anochie near Atuabo in the Western Region. The company first received a siting permit in August, 2013; and Ameri Power Limited 250 MW emergency power plants also at Aboadze in the Western Region; were all issued in 2015 (Energy Commission of Ghana 2017).

Rotan Power Limited 660 MW combined cycle at Aboadze in the Western Region was issued a permit in 2016. The following companies were issued with a wholesale supply license: Two electricity embedded generation licenses were issued to Genser Power Limited, an IPP to distribute electricity to specific consumers in the distribution network, i.e.5 MW at Tema and 30 MW at Chirano in the Western Region (Energy Commission of Ghana 2017). Siting Permits issued to potential IPPs increased from 10 in 2015 to 14 at the beginning of

2016 and expected to result in 5,863MW from 4,325 MW last year. Provisional wholesale electricity supply licenses issued to potential IPPs, as well as government-owned VRA, increased to 43 from 31 in the beginning of 2015. These total about 13,578 MW of power. Sage Power Limited was issued with an Electricity Brokerage License as well as an electricity export license (Energy Commission of Ghana 2017).

Enclave Power Company was issued with a distribution and sale license to distribute and sell electricity to customers in Dawa Power Enclave (yet to be constructed) besides its existing operations at Tema (Energy Commission of Ghana 2017). Bulk Customers of electricity operating in the deregulated wholesale electricity market increased from 33 in early 2015 to 36 in early 2016(Energy Commission of Ghana 2017).

2.5.5 Electricity Grid Codes of Practices and Regulations

The Energy Commission developed and launched the national electricity grid Code in 2010 to govern the operation of the national interconnected transmission system (NITS). The Grid Code specifies in detail the technical operational rules, codes and procedures as well as the obligations and liabilities of all players in the market (Energy Commission of Ghana 2017).

Complementary to the national electricity grid code, the Energy Commission has completed the drafting of the national electricity distribution code that sets in detail, the minimum acceptable technical standards for the development of the electricity distribution networks. The document provides guidelines and technical requirements for interconnection and evacuation of embedded generation and other relevant issues related to the safe and reliable management and operation of the electricity distribution network. The draft is currently on hold awaiting the adoption and inclusion of certain standards by the Ghana Standards Authority. The Commission has developed the Electrical Wiring Regulation 2011, L.I. 2008 to regulate electrical wiring in the country (Energy Commission of Ghana 2017).

2.5.6 Establishment of Wholesale Electricity Market

The Electricity Regulation (2008) provides for the establishment of a competitive wholesale electricity market to facilitate wholesale electricity trading and the provision of ancillary services in the National Interconnected Transmission System (NITS). The wholesale electricity market (WEM) in Ghana, the electricity transmission utility (ETU) is to ensure the procurement and dispatch of electricity from any facility of a wholesale supplier to a bulk customer and distribution utility in a fair, transparent and non-discriminatory manner.

The Wholesale Electricity Market is expected to allow for choice and competition in the wholesale supply of electricity and subsequently create an enabling environment to attract Independent Power Producers (IPPs) into the country (Energy Commission of Ghana 2017). The functions of the electricity market oversight panel (EMOP) as required under The Regulation 18 of the law (L.I. 1937) requires the EMOP to: monitor the general performance of the market administration functions of the utility; ensure the smooth operation of the wholesale electricity market; to review the operations of the wholesale electricity market and studies related to the development of the market; review procedures, manuals and electricity market rules for the operation of the wholesale electricity market; to monitor pre-dispatch schedules; to resolve disputes referred to it by market participants in respect of transactions in the wholesale electricity market; to ensure the effective and consistent application by the utility of the rules and standards of the wholesale electricity market ; ensure the long-term optimisation of hydro-electricity supply sources in the country; to make appropriate recommendations to the Commission in respect of the panel's functions, and to perform any other function conferred on it by the Commission.

A further incentive for private sector investment in the wholesale supply of electricity is Ghana's interconnection with some neighbouring West African countries, through which the market for electricity in those countries will be opened up to the IPP's in Ghana (Energy Commission of Ghana 2017). Such a market, in principle, requires to be guided by rules and regulations (backed by legislation) that should essentially reflect the government's broad policy objectives regarding the structure and administrative management and operation of the market.

The market oversight panel (MOP) was thus set up in 2015 and members of the panel had been nominated by the appropriate institutions and had since been approved by the Ministry. Ghana's electricity generation capacity is currently insufficient to meet demand, making power outages and load shedding common. The resulting impact is potentially devastating for the country's growth prospects. Traditionally, the lack of an affordable and reliable fuel supply for power generation (IMF 2017 a), coupled with ineffective institutions and an unfavourable investment climate have resulted in Ghana’s electricity sector performing poorly (Fritsch and Poudineh 2016).

2.5.7 Public Utilities Commission of Ghana

The Public Utilities Regulations Act (PURC) Act 538, 1997 established the multi- sectoral regulator by the Government of Ghana for water and electricity. The functions among others aim at promoting competition and or investments in the electricity sector and protect consumer interest. These roles come to play in an interrelated manner through the pricing of utilities. The tariff setting and approval processes have a strategic effect on the solvency of the electricity sector. The effectiveness of such an institution depends on the degree of its independence.

2.5.8 Critical Assessment of the Legal and Regulatory Framework

A critical review of the regulatory framework shows a lack of proper sequencing and there seems to be no connection between licensing of generators and other players against Ghana’s ability to absorb the inherent financial liabilities that can emanate from such entry opened to these IPPs.

Cambini and Franzi (2013) argue that the rationale behind the creation of an independent authority lies in the attempt to insulate regulators from political interference. This is aimed at influencing regulated firms' investment and employment decisions or price setting processes. This is important when the government has ownership stakes in the utility. Independent Regulatory

Authorities (IRAs) institutional design thus, has to assure agencies' independence, from a decision making point of view, from the executive power. Again the design has to assure the agencies' accountability, in front of the elected bodies and the agencies' autonomy, in terms of financial resources to be managed and expertise to be recruited in order to reduce capture risks and asymmetric information problems. Thus, the inception of truly independent agencies creates a more stable regulatory environment and this in turn has a positive impact on the investment decisions of public utilities, both in Europe(Cambini and Rondi, 2011) and in Latin American and Caribbean countries(Banal-Estañole et al. 2017; Di Bella and Grigoli 2017).

The independence of Ghana's PURC leaves much to be desired because of his appointment, lack of proper accounting system, strong influence of the state power generators, lack of skilled staff and corruption. The result has been that their inability to carry out proper assessment of the power market dynamics and to allow for increases in costs to be passed through using the automatic price adjustment in pricing design. Their performance leaves much to be desired as evidenced by the level of power sector debts (IMF 2018) because they tend to yield to political pressure conditions that tend to influence their power sector price setting decisions. In Ghana, the government still has control over gas input pricing or subsidisation. Again in many cases, there is lack of strong economic and financial analyses in justifying their intentions to effectively regulate electricity prices in Ghana. In sum, their institutional independence appears to be compromised. It is in this respect that one can argue that the empirical evidence in Ghana supports Eberhard et al (2017) earlier finding that there seems to be no correlation between the growth in IPPs and the quality of regulatory changes in many Sub-Saharan countries.

2.6.0 POWER MARKET REGULATORY STRUCTURES AND ELECTRICITY SECURITY OF SUPPLY IN GHANA

The discussion on the Ghanaian power sector regulatory structures and electricity security of supply relationship follows the five main planks of regulatory structures namely: entry, exist, regulation, accounting, and governance (Ellis et al 2014). In the power market, regulation is inextricably intertwined with governance (Zaman and Brudermann 2018) thereby leaving in place the four main planks of regulatory structures. Therefore, these four planks will serve as frameworks on which the main strands of literature for discussion in this chapter are developed.

2.6.1 ENTRY AND ACTIVITY RESTRICTIONS

The IMF (2017a) study of the Ghanaian power system shows that gas supply is dominated by state-owned institutions in the gas value chain. This is because the Ghanaian petroleum law provides a sovereign ownership over the gas in its natural form (Model Petroleum Agreement of Ghana 2000). Applying Article 14 of the Model Petroleum Agreement 2000 to the current gas discoveries implies that except for the newly identified gas fields, currently that of Sankofa fields with Eni being the international gas producing company, the earlier gas from the Jubilee fields are to be processed by Ghana Gas (Model Petroleum Agreement of Ghana 2000).

In the area of power generation, Kosmos Energy discovered the Jubilee oil and gas field in Ghanaian waters in 2007. Estimated to hold 3 billion barrels of oil (bbl) and 335billion cubic feet (Bcf) of natural gas, the discovery is of great significance for Ghana's energy sector. The oil production at the Jubilee field began in 2010. In the wake of the Jubilee discovery oil and gas exploration off Ghana's coast intensified, leading to further discoveries. The Tweneboa, Enyenra, and Ntomme(TEN) oil and gas fields are estimated to contain gas reserves of 353Bcf, while the Sankofa and Gye Nyame non-associated gas fields are estimated to hold approximately 1,168 and 982 Bcf, respectively. Utilisation of gas in Ghana has so far only taken place in the power sector. All thermal plants, including those of IPPs, are located in the coastal cities of Tema and Aboadze (near Takoradi), where they are directly supplied with gas from the West African Gas Pipeline (WAGP).

Since 2011, and in response to the discovery of the Jubilee oil and gas field, Ghana has been expanding its gas infrastructure to facilitate the commercial utilisation of gas reserves in electricity generation. An off shore gas pipeline has been constructed to connect the Jubilee field to the coastal town of Atuabo in Ghana's far west. From Atuabo, a 100km long onshore pipeline was built to supply gas to the thermal power plants in Aboadze. The building of a gas processing plant started in 2011 in Atuabo, and the plant became operational eventually after completion of the project suffered from severe delays. Although the infrastructure needed to initiate the domestic utilisation of gas at low volume is in place, following the completion of the gas processing plant in Atuabo. The experience of developing a domestic gas sector has been difficult for Ghana. Gas from the Jubilee field had originally been scheduled to be available as fuel for thermal generation plants by late 2012, but various incidents and cost explosions have caused delays in the development of the necessary infrastructure.

Ghana's current total dependable installed capacity for electricity generation amounts to 3,401MW (Energy Commission of Ghana 2017), of which 41.16 percent is hydroelectric, 58.77percent is thermal, and 0.1percent is renewable. Despite the addition of approximately 2,000MW of capacity through the construction of thermal plants since1998 – before which the country exclusively relied on hydroelectric power generation – the installed capacity does not currently meet the electricity demand in Ghana. According to the World Bank projections, Ghana is 625MW capacity short of satisfying total electricity demand (World Bank 2017).

Ghana's hydroelectric generation potential is already largely exhausted, while the large-scale installation of renewable electricity generation types, such as solar and wind, is not feasible in a region which has such little experience with renewable energies. Taking into consideration Ghana's economic growth trajectory and its expanding population, coupled with its geographic endowment, there the need to make the necessary efforts to catch up with Ghana's rising demand for electricity. The government efforts are largely focused on increasing thermal power generation (Fritsch and Poudineh 2016). Tables 2.5 and 2.6 below show the generation mix of electricity in Ghana.

Table 2.5: Power Generation Mix in Ghana

Plants	Installed Capacity (MW)	Dependable Capacity (MW)	Available Capacity (MW)	Fuel Type	Availability Factor (%)
Akosombo GS	1,020	900	375	Water	100%
Kpong GS	160	140	105	Water	72%
TAPCO(T1)	330	300	300	LCO/Gas	85%
TICO(T2)	330	320	320	LCO/Gas	88%
TT1PP	110	100	100	LCO/Gas	85%
TT2PP	49.5	45	30	Gas	85%
MRP	80	70	40	Gas	80%
Trojan	20	18	18	Diesel/Gas	85%
VRA Solar Plant	2.5	0	0	Sunlight	18%
SAPP	200	180	180	Gas	92%
CENIT	110	100	100	LCO/Gas	92%
Bui Gas	400	360	345	Water	85%
Total	2,812	2,533	1,895		

Source: Energy Commission of Ghana: National Energy Statistics 2017(12).

Table 2.6: New Thermal and Alternative Renewable Energy Sources in Ghana in 2016

Plants	Installed Capacity(MW)	Dependable Capacity(MW)	Fuel Type	Availability Factor
KTPP	220	200	Gas/Diesel	85%
VRA/AMERI	250	230	Gas	90%
Karpower Badge	250	225	HFO/Gas	90%
TT2PP-X	36	33	Gas	85%
SAPP(2)	186	180	Gas	85%
Central Region Solar	20	0	Sunlight	15%
Total	962	868		

Source: Energy Commission of Ghana: National Energy Statistics 2017(13).

The state-owned Volta River Authority (VRA), Ghana's main electric power utility corporation – is in the process of upgrading simple-cycle plants to combined-cycle plants (VRA 2015). Together with thermal developments, the VRA is planning to add1,000 MW of thermal capacity within five years.

Ghana's thermal power plants have been (and are being) built with the intention to fuel them with natural gas supplied to Ghana through the West African Gas Pipeline (WAGP). Contrary to the expectations of the Ghanaian government, the WAGP has hitherto been unable to fulfil its role as a reliable supplier of gas. Whereas 120m MMscfd (million standard cubic feet per day) of gas exports were contractually agreed upon between the Nigerian and Ghanaian governments, this quantity has never been provided by Nigeria due to high domestic demand and political instability in Nigeria's oil-producing regions. Even if Ghana was supplied with all of the contracted 120MMscfd, this quantity would still not be enough to fuel Ghana's existing thermal power plants, let alone the future thermal developments (Energy Commission 2014: 43).

Due to the lack of reliable gas supplies, Light Crude Oil (LCO) has been the predominant fuel in Ghana's thermal power generation. Though LCO is less complex to import, its use in electricity generation is extremely costly: compared to gas, thermal power generation using LCO is three times more expensive (World Energy Council 2013: 7). Since 2010, oil from Ghana's Jubilee field can be refined in the coastal town of Tema to be used as LCO in Ghana's thermal plants. Yet this only makes LCO marginally cheaper, as the opportunity cost of using Ghana's oil as fuel for thermal generation is high.

To secure a comparatively inexpensive fuel for thermal generation capacity, the availability of which the VRA and Independent Power Producers (IPPs) can rely on, is thus a key challenge in ‘curing’ Ghana's electricity sector. The significance of this situation is elevated by the steadily decreasing water levels of Lake Volta at the Akosombo Dam – home to Ghana's crucial1,020 MW Akosombo hydroelectric plant. There is no development of new mini –hydro plans in the pipeline over other major rivers like Ankobra and Pra. Again solar power which could easily be deployed for every household in Ghana has not been put into the policy framework for any serious implementation (Gyamfi et al.

2015). Thus, considering the existing power generation capacity, Ghana's electricity sector appears to be in a crisis (IMF 2017b).

2.6.1.1 OWNERSHIP STRUCTURES OF GHANA'S POWER SYSTEM

The second strand of literature relates the licensing regime to the ownership of licensed power generators including IPPs and their effect on electricity security of supply (Massie et al 2015). As at mid-2017, there are 10 thermal plants in addition to three hydro power generation plants owned by the VRA operating in Ghana (Energy Commission of Ghana 2017). Seven of these thermal plants are subsidiaries of foreign energy firms and their share of power production is estimated to be 30.4%.The power sector therefore has two ownership structures namely, public (also known as state-owned (SO)) and private independent power producers (IPPs). The private power producers are further classified into foreign and domestic. Joint state and private producers also exist.

Table 2.7 provides an overview of the shareholding of the power generators in Ghana. As at December 2016, 6 of the power generators were state-owned. The state has a controlling interest through direct and indirect shareholding by the government and the state-controlled Volta River Authority (VRA) The SOs account for 70% of thermal generation, one of the highest in the Sub-Saharan Africa region.

	Table 2.7. Overview of the Shareholding Structure of Power Generators in Ghana		
	Generator	**Classification and Mode of Entry**	**Main shareholders at end of 2016**
1	Akosombo	State-Owned Power Generator (SPG)	Government of Ghana/ VRA 100%
2	Kpong	State-Owned Power Generator (SPG)	Government of Ghana/VRA 100%
3	Bui	State-Owned Power Generator (SPG)	Government of Ghana VR 100%
4	TAPCO (T1)	Foreign/IPP	Abu Dhabi National Energy PJSC(TAQA) : 90% Non-Controlling Interest/VRA : 10%
5	TICO(T2)	Foreign/IPP	Abu Dhabi National Energy PJSC(TAQA) : 90% Non-Controlling Interest/VRA : 10%
6	TT1PP	State-Owned Power Generator (SPG)	Government of Ghana VR 100%
7	TT2PP	State-Owned Power Generator (SPG)	Government of Ghana VRA 100%
8	MRP	State-Owned Power Generator (SPG)	Government of Ghana VRA 100%
9	Trojan	Foreign /IPP	Trojan General Contracting, subsidiary of Royal Group UAE 100%
10	Sunon Asogli Power (Ghana) Limited (SAAP)	Foreign /IPP	Shenzhen Energy Group Limited : 60% China Africa Development Fund: 40%
11	Cent Energy Ltd (CEL)	Quasi - State/ Private-owned Power Generator (SPG)	GECAD 100% USA
12	Karpower Badge	Foreign /IPP	Turkish Firm rented Power Badge 100% ownership
13	VRA/Ameri	Joint State/Private-owned Power Generator	Government of Ghana VRA/ Africa and Middle East Resources Investment Group LLC 100%.
14	VRA Solar Plant	State-Owned Power Generator (SPG)	Government of Ghana VRA 100%

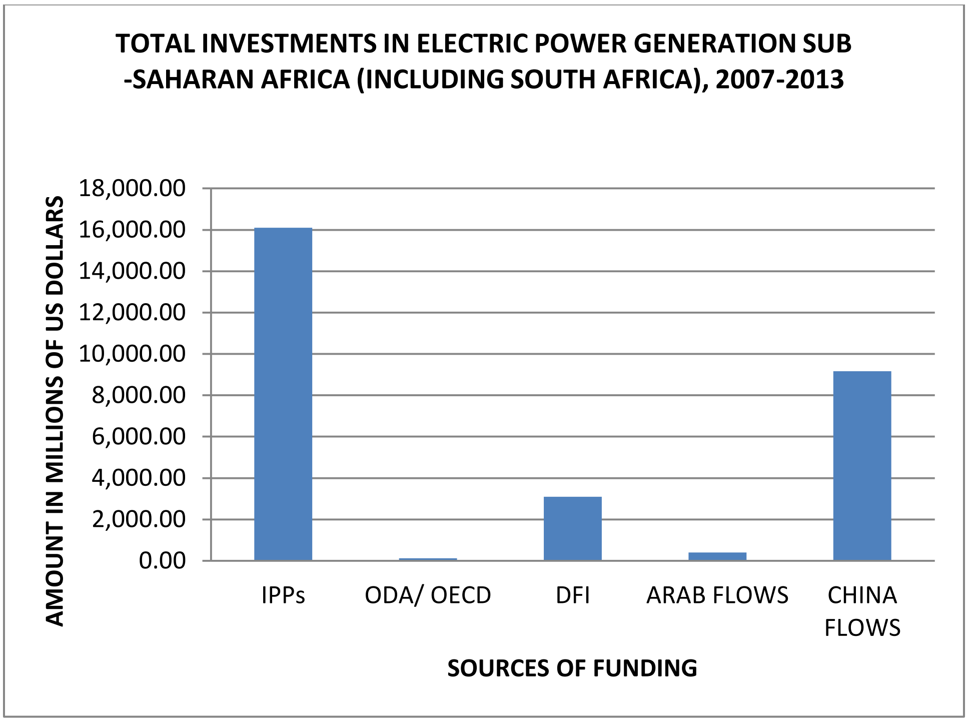
Source: Ministry of Energy; Annual Reports of the 14 Generators

Comparatively, 126 IPPs are present in 18 countries of Sub-Saharan Africa.

Together, they account for more than 13 per cent of the subcontinent's total installed generation capacity—25 per cent if South Africa is excluded (Eberhard et al 2016). This is a notable share of total generation, given that most IPP investment had occurred in just the past few years. However, IPP investments could be much larger and less concentrated. South Africa alone accounts for 62 per cent of IPP capacity; most of the remaining projects are located in a handful of countries.

Many more African countries could and should benefit from such investments (Eberhard et al 2016) as shown in Figure 2.2 below.

Figure 2.2 Comparative Ownership/ Investments in the Power Generators in Sub-Saharan Africa 2007-2013

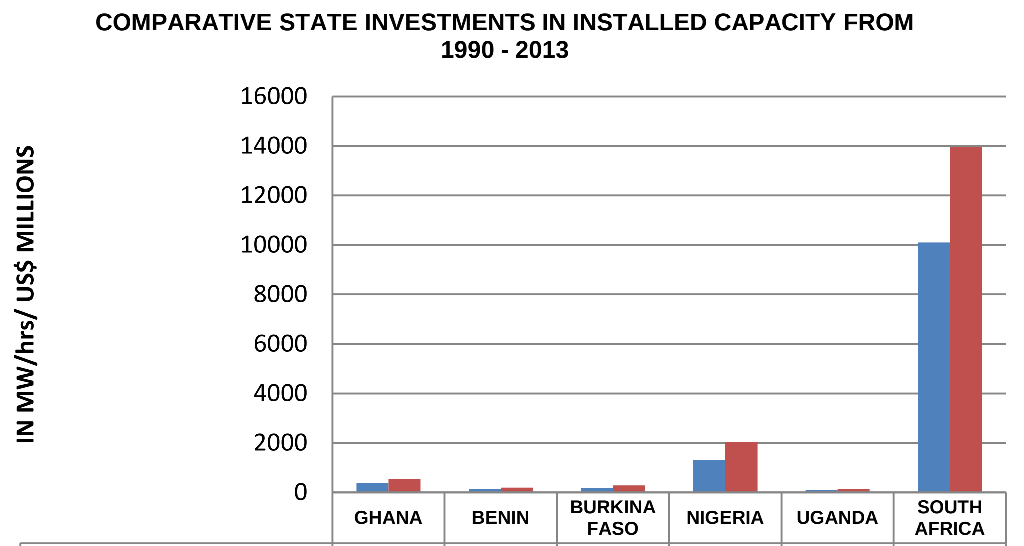


Source: Adapted from Eberhard et al 2016 and modified by the Author.

The ownership structure of the power generators brings together diverse public institutions, with different mandates and objectives.

First is the shifting trend in the ownership of power generators in Ghana as compared with other countries in Sub-Saharan Africa where ownership is largely by the state. The share of foreign power generators in Ghana is increasing.

Figure 2.3: Comparative State ownership and investment in power generation assets in SSA



	GHANA	BENIN	BURKINA FASO	NIGERIA	UGANDA	SOUTH AFRICA
INSTALLED CAPACITY	379	145	177	1,298	90	10,098
INVESTMENTS (US $, MILLIONS	546.60	189.80	279.00	2043.80	129.60	13954.00

Source: Adapted from Eberhard et al. 2016 and modified by the Author.

Figure 2.3 shows the comparative efforts by governments in power sector investments or holding of power assets in six major economies in Sub-Saharan Africa from 2007-2013.   Figure 2.3 therefore presents a comparative data on the relative contribution of governments that do pursue a similar strategy in the management of their energy sector notably Ghana, Nigeria and Uganda (Eberhard et al 2016).

The ownership structure has implications on the level of electricity security of supply. The empirical literature shows that state-owned gas and power generators have different objectives from international oil and gas producing companies (Duval et al 2009).

There are recent cross-country studies on the gas and power producing ownership structure and electricity security of supply capturing the Ghanaian power sector, from authors including Eberhard et al (2011) and IEA (2016). In addition, there are many country studies on Ghana by Gyamfi et al (2015); Fritsch and Poudineh (2016); Eshun and Amoako Tuffour (2016); IMF 2016; and IMF 2017. The discussion by Eberhard et al (2011) which relates to Ghana's power sector is based on the performance of the state-owned power generation firms. They conclude that for developing countries including Ghana, governmental and governance problems have made the state-owned producers less credit worthy as offtakers thereby affecting the underlying contractual drivers to support any investor confidence into the power sector. Their findings were confirmed by similar studies by Kojima et al (2014) whose discussions are based on subsidies and cost recovery issues in Sub-Saharan Africa. The recent findings by the IMF (2016, 2017b) reinforce the challenges facing the entire power sector value chain in Ghana.

In fact, the restructuring of state-owned VRA and the liberalisation of generation allowed the entry of foreign IPPs and contributed to higher production and not competition because Ghana is capacity short.

Because of the huge investments required for power projects, a review of the energy policy of the Government of Ghana shows that the design of the entry appears to be less stringent. For example, the new government in 2017 had to review all contracts given the lack of proper economic analysis of the cost structure on energy prices once they come on stream. A proper method of evaluating costs has to be put in place as investors are being encouraged to support the generation process. The recent review of the Government of Ghana and Ameri Group's BOOT contract is a typical case in Ghana where the necessary consents and approvals were assumed and not legally followed (Ministry of Energy 2017).

Again there is no attempt to pursue any structural regulation, which may involve restrictions on power sector investment activities due to capital scarcity. Rather the regulation is geared towards the diversification of power generation sources. The recent Renewable Energy Act (2011) has seen Ghana having one of the best renewable energy potential in the ECOWAS sub-region. Of the total 1411 MW medium to large scale identified renewable energy projects in the ECOWAS sub-region (Lugmayr 2011), 11.5 per cent are located in Ghana (Gyamfi et al 2015). The literature is also scarce on the effects of the emergence of cross-border power trading that have seen the growth in their cross-border transactions, which are still not regulated effectively.

Ghana's energy sector is increasingly being dominated by foreign-owned gas producing and thermal investors. The implication of the dominance of foreign power player is that, currency risk which relates to the devaluation of local currency; convertibility risks in converting the local currency to foreign currency and transfer risk involving the transfer of foreign currency out of Ghana become important risks. There is also the exposure risks arising from the way contracts are structured and the security guarantees in the form of standby letters of credit. The letters of credit (LCs) are typically structured as confirmed and irrevocable and can therefore be enforced with little control from the state in relation to the rental of power plants and some BOOT contracts. Using the Ameri contract as an example, the wording of the standby letter of credit (SBLC) established, differs significantly from that contained in the Agreement that went to Parliament. Secondly, the wording of the SBLC is too wide as it gives Ameri the opportunity to withdraw all $51million after collecting the required payments. There is no requirement to give notice to the Government of Ghana (GoG) before calling on the SBLC. As it stands GoG is simply relying on Ameri's goodwill not to draw on the SBLC because Ameri can, for example, call on the SBLC even when there is a genuine invoice dispute between the parties to the BOOT Agreement. This is in addition to Ameri making a commission in the sum of US$ 150 million over the term of the Agreement (Ministry of Energy 2017).

The use of such instruments in host-investor contracts requires that the monitoring of these gas and power producers needs to be strengthened (Kashi 2015).

2.6.2 ACCOUNTING AND ELECTRICITY SECURITY OF SUPPLY

The regulatory system requires that power firms account for their activities in a transparent manner (IMF 2017). Accounting is necessary to promote transparency given the opacity of many gas-to-power value-chain level transactions between the suppliers and their customers.

The enhancement of Ghana's security of energy supply through domestic utilisation can be justified from the perspective of sustainability (Larsen et al 2017). Secondly, the justification emanates from an accounting perspective (Rhodes et al 2017). The third involves the investment theory perspective which indicates a potential return on assets (ROA) and minimised transaction costs in utilising the domestic gas for power (Gulbrandsen et al 2017). The major limitation is from the risk of incomplete contracts and the regulatory gaps that help to create the balance between investor expectation and the Ghanaian regulatory regime.

Fritsch and Poudineh (2016) citing Cho (2010) show that many countries around the world began the development of their domestic gas sectors with the advancement of the gas-to-power market, including Colombia, Thailand, Israel and Tanzania. Not only does gas-to-power utilisation generate a high economic value of gas compared to most other domestic utilisation opportunities, it also has positive spill over effects as reliable and sufficient electricity supply enables growth. On the other hand, countries such as Yemen, Nigeria (Thurber and Chang 2011), and Indonesia have prioritised gas exports (Fritsch and Poudineh 2016). This is the case even though the need for gas as a fuel for thermal electricity generation in these three countries is no less than in Tanzania or Thailand.

However, for reasons examined below, some countries decided to export their gas reserves instead of utilising them domestically in the gas-to-power market (as well as other sectors at a later stage). To pursue a mixed strategy of creating both a domestic gas-to-power industry and export facilities is not an option in Ghana's case: the required infrastructure investments for both options relative to Ghana's total proved gas reserves are unviable (Nexant 2014: 9).

According to Kojima (1999) and Chandra (2006:99) gas commercialisation and approximate gas requirements for various commercialisation options which power projects is one of the options is adapted and presented below (Chandra 2006).

The option to use the gas for agricultural production to increase food production through commercial farming will have the multiplier effects of reducing the cost of living, foreign exchange from export of food, raw materials for industry. There is also the opportunity to alternatively develope ethanol from sugar cane which can provide fuel and has power generation potentials. This can change the nature of technical composition of the power generation base as experienced in Brazil with the use of biomass (Signorini et al 2015).

The commercialisation options as shown in Table 2.8 provide trade-offs and pitfalls with the use of gas from the marginal fields. Ghana’s existing economy is mainly agricultural.

Table 2.8 Gas commercialisation Options

Gas Commercialisation Options			
Product	Plant size	Approximate Daily Gas Feed MMcfd	24 year reserves needs
Iron (DRI process)	1MTA	30 MMcfd (+5 to convert DRI to steel)	0.3 tcf
Fertilizer (ammonia/urea)	1MTA	60 MMcfd	0.5 tcf
Methanol(CNG)	1MTA	80 MMcfd	0.7 tcf
Electricity (CC generator)	1,000MW	125 – 130 MMcfd	1.1 tcf
Gas-to Liquids (GTL)	10,000bpd	100 MMcfd	0.9 tcf
Liquefied Natural Gas (LNG)	1MTA	133 MMcfd	1.2 tcf
Source: Kojima, M. (1999) Commercialization of marginal gas fields. The World Bank. *Energy Issues*. No. 16 (January). The World Bank			

According to World Bank estimates in 2013, the cost of associated gas from the Jubilee oil field to the Takoradi thermal plant equals $2.25/MMBtu (World Bank 2013:37). Comparing this to the cost of light crude oil (LCO) at $17.24/MMBtu, Ghana could save $14.99 on every MMBtu that is produced with gas instead of light crude oil. Placing this figure in a recent context, it has been estimated that in 2014 it costs the VRA an additional $1m per day to use light crude oil as compared to gas received from Nigeria through the WAGP at a cost of $8/MMBtu (World Bank 2013: 12).

Another financial incentive for domestic gas utilisation is that using gas as a fuel for the country's thermal plants will free up oil – previously refined into light crude oil – for other purposes such as export. While Ghana's non-associated gas reserves are more expensive to produce, at a cost of $8.50/MMbtu it is feasible for the domestic gas-to-power market to continue operations once associated gas reserves are depleted.

Fritsch and Poudineh (2016) argue that if operations and maintenance costs do not differ based on gas or light crude oil used as fuel in thermal plants, associated gas could be sold to the VRA and IPPs at a price just below the price of light crude oil. They stress that even if gas was sold to thermal plants at a marginally cheaper rate than light crude oil, this would still create an economic incentive for the VRA and IPPs, as costs can be cut and profit margins improved. In practice, thermal plants have been heavily subsidised by the Ghanaian government as electricity generation tariffs have not been adjusted to take into account the need to use expensive light crude oil for thermal power production. Instead of selling gas to thermal plants at its economic price, one can thus assume it will be offered at a lower price (for instance $8/MMBtu – the same price at which West African Gas Pipeline(WAGP) supplies gas) thereby replacing existing direct subsidies. Note that the supply of WAGP gas is contractually restricted and that there is no mechanism for increased supply in exchange for higher prices by Ghana.

This implies that WAGP gas is not a barrier for domestic gas price data cost exceeding the price of WAGP gas as the VRA and IPPs could not purchase more WAGP gas at $8/MMBtu or even a higher price.

From an economic value point of view, the incentive for Ghana to pursue an export-oriented gas strategy is much smaller than the incentive to utilise the gas in the domestic gas-to-power market. While Ghana could generate government revenues from selling gas on the world market at an economic net back gas price of $2.2/MMBtu, the expected savings achieved from using gas instead of light crude oil in the country's thermal plants far exceed the expected export revenues. Associated gas can be supplied to thermal plants at approximately $2.25/MMBtu as opposed to$17.24/MMBtu for light crude oil (Fritsch and Poudineh 2016).

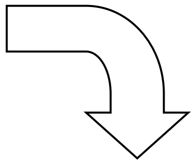
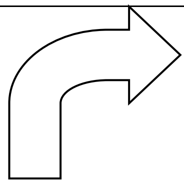
Put differently, with every MMBtu of domestic associated gas used in thermal power generation the state-owned VRA saves $14.99, while exporting the same MMBtu would have generated $2.2 in government revenue. This substantial gap of nearly $13 per MMBtu in increased economic efficiency grows further if one accounts for the revenues generated from oil sales, which would no longer need to be used in the form of light crude oil in thermal power production (Fritsch and Poudineh 2016).

An alternative application of gas resources to petrochemical production has some limitations, since the price of feedstock is constrained by the price of the final commodity being produced. Normally, this constraint results in low price requirements for gas supply. The World Bank (2013) using the prevailing commodity prices and capital costs, the maximum sustainable feedstock gas price is estimated at US$4.00–7.00/MMBtu, prices that in many cases will be lower than Ghana's weighted average cost of gas. Looked at on a marginal cost basis, supplying gas to petrochemical projects is even less appealing, since it would require incremental supplies of non-associated gas and/or imports at prices on the order of US$10–15/MMBtu.

The Government should place a clear priority on satisfying the power sector demand for gas before considering supply to petrochemical projects. At a minimum, the Government should wait three to six years before committing gas to petrochemicals to allow time for the major near-term gas supply uncertainties to be resolved.

In a deregulated power market, the order in which power plants are turned on is called dispatch stack. This is a last on, first off ordering similar to a stack of plates as shown in Figure 2.4 below.

Figure 2.4 Generation Stack based on Cost

Last on			**First Off**
Highest Cost	**Diesel Peaker (Light Oil)**		**Last Dispatched**
	Gas Turbine		
	Steam Turbine Oil (Heavy Oil)		
	Steam Turbine Gas		
	Combined cycle Gas		
	Coal		
	Nuclear		
Lowest Costs	**Hydroelectric**		**First Dispatched**
Edwards, D. W.(2010:259) ***Energy trading & investing Trading, Risk Management, and Structuring Deals in the Energy Markets McGraw Hill New York***			

The choice of technology should be guided by environmental, health and safety guidelines for thermal power plants. Environmental issues in thermal power plant projects primarily include the following: air emission; energy efficiency and green gas emissions; water consumption and aquatic habitat alteration;

effluents; solid wastes; hazardous materials and oil; and noise (IFC 2008). The environmental principles are intended to serve as a common baseline and framework for the implementation by each equator principle financial institution (EPFI) of its own internal social and environmental policies, procedures and standards related to its project financing activities.

Banks will not provide loans to projects where the borrower will not or is unable to comply with their respective social and environmental policies and procedures that implement the Equator Principles.

Empirical studies by Kashi (2015) on thermal power plants show the use of gas turbines as the main generation technology. These power plants have become a popular choice for IPPs for a number of reasons. They provide operational flexibility and can be constructed for a wide range of capacities. They can work on various sources of fossil fuel including natural gas, liquefied natural gas (LNG), heavy fuel oil (HFO), diesel, methane, and ethanol, among others. Again they can be constructed in operational phases, and have a relatively short construction period.

Many independently owned and operated thermal plants have been constructed in developing countries over the past two decades. A thermal power plant with gas turbine as the main mover can take the form of an open –cycle gas turbine (OCGT) or a combined –cycle gas turbine (CCGT). The equipment cost of such OCGT or CCGT power plants is a substantial element in their total investment. Combined-cycle plants are more fuel efficient and, at the same time, more expensive than open-cycle plants OCGT power plants and CCGT power plants can convert about 35 per cent and 55 per cent, respectively of the energy contained in fossil fuel into electrical power. The majority of the remaining energy is in the form of heat, which can either be exhausted into the environment or utilised for industrial or municipal heating.

In light of the 2007 discovery of natural gas reserves in Ghanaian waters, earlier studies by the World Bank in 2013 show that the utilisation of gas reserves into power generation is an economically superior strategy compared to an export-oriented utilisation scheme (World Bank 2013).

2.6.3 REGULATION (SUBSTANCE AND GOVERNANCE) AND ELECTRICITY SECURITY OF SUPPLY

Firms in the power sector in Ghana and in particular the private companies have adopted shareholder value maximisation as their business philosophy. The shareholder value (SHV) maximisation model (Jensen and Meckling 1976; Johnson et al 2011) and in keeping with the scope of operations hypothesis by Boone et al (2007) stresses that the governance structure should reflect the scope and complexity of operations.

The governance of any power system follows the standard principal agency theory. The state being the principal and exercising its sovereign right through the Ghana National Petroleum Corporation (GNPC) and Ghana Gas (the agents) takes the associated gas from the Jubilee fields to the various gas – power producers. The VRA being the state-owned institution for power generation provides the conduit for power generation through the various power plants. Again being the single offtaker, it sells the gas to the various IPPs as a means to monitor the main input cost and also for settlement of debts. One rationale for such a governance system is explained from the transactions cost theory which stresses two things.

The first is the issue of cost cutting against the issue of market orientation (Thurber and Chang 2011). Market orientation will ensure that in the midstream open bidding for infrastructure contracts, utilisation ensured through long –term contracts for gas, incentives and guarantees to reduce risk and open pipeline access.

In the downstream market orientation requires that end use prices are based on supply and demand. Again environmental and other externalities are put into price. Ghana appears to be pursuing a centrally planned approach to the governance of its gas to power value chain. Government is building infrastructure itself. Transport tariffs are regulated and pipeline access is restricted and controlled by VRA and BOST.

In the downstream, users are mandated by government through the IPP fuel risk absorption adopted by government with the low cost of capital through tax incentives for favoured industries notably the gas –powered IPPs. For example the Government of Ghana (GoG) approved a wide exemption of taxes for Ameri and its third parties. Basically, Ameri and all its affiliates and sub-contractors and third parties are not liable to pay any form of tax whatsoever in the Republic of Ghana (Ministry of Energy 2017). The second is the need for long term contracts for the recovery of investments and to attract investments into the energy sector. Long term contracts will deal with long term demand risks (De Maere d'Aertrycke et al 2017).

The problem of governance which emanates from the transaction costs relates to investor – host nation conflicts where the settlement of debts is delayed due to budgetary constraints and the poor collection of utility bills by the main distributor the ECG. This affects the timely recovery of investments. An additional issue is the level of system losses currently over 25 per cent (Energy Commission 2017).

The main critique of the literature is that they are limited in scope and depth in relating corporate governance to electricity security of supply in Ghana. The empirical literature on corporate governance and electricity security of supply in Ghana is scarce and the few by Eberhard et al (2011) raises the risks associated with vertical integration such as bureaucratic failures and public policy argument when antitrust concerns become an issue. For antitrust policy this means that a vertical integration is no longer a production function but a governance structure. Integration thus constitutes a problem only where the market structure supports strategic behaviour. For example if vertical integration leads to market foreclosure, then foreclosure could be used as a method to increase market share which is costly to the firm attempting it and thus constitutes a behaviour which is irrational(Kirsten 1999). Little has been written on issues relating to board size, structure, CEO tenure but only on firm performance and efficiency (Eberhard et al 2017; IMF 2017b)

2.6.4. EXIT AND ELECTRICITY SECURITY OF SUPPLY

The literature relates to the existence of stranded costs due to new technologies and attempts at the decarbonisation of power production. Beginning with gas production and infrastructure, decommissioning costs and issues relating to pollution require that the polluter pays principles are put in place. This is in line with Ghana's Model Petroleum Agreement (2000). The traditional method of protecting the environment has been through regulation. The current environmental regulation under the Environmental Protection Agency Act, 1994 Act 703, and the Environmental Assessment Regulations,1999(L.I. 652) of the EPA is a light –handed regulatory framework. The function of EPA is to adopt regulations that correct for market imperfections, oversee compliance of international oil companies with the Ghana National Petroleum Corporation (GNPC) to reduce uncertainty for investment. Other regulations have been concerned with the technical requirements related to resource management issues such as environmental discharges, surface access in line with the precautionary principles.

Market mechanisms can be defined as mechanisms designed to act via an economic signal in the market to which players on the upstream petroleum sector respond to (Patricia et al 2009). Economic instruments fall into five main categories: subsidies, charges, deposit refund system, market creation and financial enforcement incentives (Patricia 2002). The polluter pays principle is more related to market mechanism which is applied after the contractor has flawed the regulations. This is reactive and still leaves the question to be answered as to what extent can these international principles be tacitly incorporated in the Model Petroleum Agreement adequately and effectively protect the Ghanaian environment and any future considerations?

In the generation and distribution sectors, there is little literature on any stranded assets in the Ghanaian power sector. This can be explained from the fact that capacity is inadequate, the market is immature and there is no substitution for technology that has fallen out of societal expectation. The existing facilities were hydro. The plants for future decommissioning is likely to be the diesel fuel plants but most are mixed fuel plants that use both gas and diesel (Energy Commission 2017).

2.7.0 SUMMARY OF CRITIQUE AND GAPS IN THE LITERATURE ON GHANAIAN REGULATORY STRUCTURE AND ITS ELECTRICITY SECURITY OF SUPPLY OBJECTIVES

The critique of the literature on Ghana's regulatory structure and electricity security of supply follows two strands. The first follows a strand of literature which examines how regulators have effectively implemented measures that provide investor protection in their respective jurisdictions or in Ghana. The second is the critique of the literature on Ghana on the basis of the four planks of its power sector regulatory structure. The aim is to identify the gaps in the literature.

The main critique is that the regulatory framework concerning tax and fiscal stability clauses lacks standardisation of power purchase and investment agreements, as these clauses tend to vary to reduce transaction costs for both project developers and investors. This is because some of the power projects cannot be situated at the designated free zones. The literature is limited on the issues relating to capital allowances. Capital allowances are granted to a person are to be taken in the year granted and cannot be deferred. The tax law generally states that assets acquired such as plant and machinery will attract a 30% capital allowances on a reducing –balance basis (PkF Ghana 2017). Likewise buildings, structures and works of a permanent nature attract a 10% capital allowance on a straight line basis.

In designing a fiscal power sector regime, there are conflicts inherent in the respective objectives of investors and public policy given the role electricity plays in modern societies. However, recent works on power and infrastructure projects indicate that the use of flexible, neutral and stable regimes can facilitate the reconciliation of objectives (Auriol and Picard 2013). A recent study by the IMF, OECD, UN and World Bank in 2015 on options for low income countries' effective and efficient use of tax incentives for investment did not include Ghana but some countries in the West African region.

Tax incentives have been found to be redundant and in keeping with UNIDO (2011) that stabilisation related incentives were more attractive to investor interest than direct tax incentives or incentive packages (IMF et al 2015). Stability measures included economic stability, political stability, cost of raw materials, the transparency of the existing legal framework, local markets, bilateral agreements and treaties which technically form the basis for any economic and fiscal stabilisation agreements.

Most tax incentives are found to be redundant as compared with stabilisation incentives (UNIDO 2011) when their effective use to attract investments into the power sector is incongruous. They are unable to yield the desired social benefits in broader welfare terms notably an adequate generation capacity to satisfy demand at acceptable consumer prices i.e. affordability which is synonymous with security of supply. Again the literature is silent on intellectual property rights in the energy sector. This is in the context of project design documents and feasibility studies that are submitted as part of the licensing process.

The additional gap in the literature has been that, the recent work by Fritsch and Poudineh (2016) had focused on identifying the gaps in the regulatory structure of gas-to –power sector in Ghana. The recent work on electricity security by Gyamfi et al (2015) had considered the possibility of using alternative energy notably solar and other renewable which may show positive signs but only complementary to the immediate and medium term security of electricity challenges. Again the focus was not as comprehensive as it is in this research which focuses on the entire power generation and security. Most studies in excess capacity economies had focussed on the composite sources of electricity which included nuclear, gas-power, wind and other sources (Signorini et al 2015; Dastan and Selcuk 2016; Castro 2017; Larsen et al 2017) in their comparative assessments using Brazilian, Turkish, British and European cases, respectively. Several cross-country studies on electricity security which included Ghana for example by the World Bank, Energy Sector Management Assistance Programme(ESMAP) and the Climate Investment Fund (2016) recent work on regulatory indicators for sustainable energy (RISE), Eberhard et al (2017) and Best and Burke (2018) did not cover the current period of study. Again the data had focussed largely on the pre-power crisis period.

Therefore, the current work is to fill the gap of exclusion bias due to the period used to select the samples set, increase the sample size and increase the currency of the data in assessing the security of electricity supply in Ghana. Using power market data from 2007 to 2016, this research examines both electricity security and performance matrices and in particular the relationship between the electricity security and power market regulation and performance variables in Ghana.

2.7.1 CRITIQUE OF THE LITERATURE ON REGULATORY STRUCTURES AND THE FOUR PLANKS OF REGULATION

The literature on Ghana's regulatory structure and electricity security of supply follows four strands. The first strand considers the entry into and exit of firms from the power sector. It considers the effects of deregulation and liberalisation in the generation sector to attract IPPs, while the distribution sector in particular is under consideration for competition in Ghana. The transmission remains a natural monopoly except where the development of three possible energy supply solutions namely, grids, minigrids, and stand-alone systems have been made possible due to technological change. The rapidly declining costs of solar PV now offering the possibility of complementing grid expansion with decentralised off-grid solutions, potentially accelerating the pace of electrification, particularly in remote areas, also suggest that they are being pursued not as substitutes but as complements. The main critique is that the literature does not consider or is scare on the optimisation and sequencing of the needed generation mix. Again the available literature is limited on the auctioning of the estimated power market potential, selection of IPPs and discounting rates for projects approved.

Again the literature covered periods up to 2013 while this research extends the data up to 2016. More importantly, the methodologies used are largely normative and they differ contributing to mixed results. Overall the granular effects of foreign participation in gas-to-power generation are not analysed. The research will take into account the key providers of power which complement the data used by the World Bank (2013) and Fritsch and Poudineh (2016).

Again the use of econometric techniques to explain the causality between key variables and the security of electricity supply provides a more rigorous approach than the traditional analysis based on assumed relationships. The use of comparative legal methodology to examine the regulatory framework in Ghana is scarce and limited. This research will complement the econometric analysis with the comparative method to identify gaps in the legal framework that are required to guarantee long term sustainability of the power sector value chain in Ghana.

The second strand looked at accounting and electricity security of supply. The current work while employing the marginal and full costing approaches in the assessment of performance of power firms will also look at the price of the power which feeds the entire value chain to ascertain the viability and degree of subsidisation of power in Ghana. It therefore considers how financial efficiency affects the security of electricity supply as it inherently deals with stranded costs and legacy debts. These challenges have also undermined the financial viability of power generating firms and electricity security of supply.

The third strand looks at the governance and electricity security of supply. It takes the governance structure from the degree of transaction costs to determine the nature of contracts and the design of the market. In a developing country like Ghana, the assurance of demand from the PPAs offered by the government is a means to reduce transaction cost and provide a signal for long term availability of negotiated price and market. The existing literature on Ghana by Eberhard et al(2011, 2017) do discuss how the approach to the sale of power affects the supply of electricity but used a comparative approach. The literature stresses on the effect of deregulation and liberalisation but does not consider the transaction costs, their manifestation experienced by investors in the power sector.

This research will examine also the impact of governance on electricity security of supply differently and indirectly through ownership structures and management style. The next chapter will review prior empirical studies on the relationship between electricity security and regulatory structures using examples from the developed and developing countries in order to identify the other gaps in the literature.

CHAPTER 3

EMPIRICAL LITERATURE REVIEW

3.1 INTRODUCTION

This chapter reviews the theoretical and empirical literature on power market regulatory structures and electricity security of supply. It reviews the literature on the four key planks of any well-defined power sector regulatory regime: entry - deregulation and competition or liberalisation; exit – that is stranded, environmental and decommissioning policy; accounting – that is, estimating the standard cost of electricity, cost recovery, auditing and valuation policy; and governance - contractual framework and how they affect power sector sustainability. The literature review therefore focuses on the main strands of literature on how these four key planks affect power sector security of supply.

3.2.0 POWER SECTOR REGULATION AND ELECTRICITY SECURITY OF SUPPLY

The legal perspective of regulation is built upon a dominant strand of regulatory scholarship that views the law as an instrument used by the state to achieve the community's chosen collective goals. Regulatory scholarship of this nature is concerned primarily with effective problem-solving. These approaches tend to downplay the non-instrumental values, institutions and ideals which lawyers often emphasise as the most obvious being the values and institutions encapsulated within the rule of law ideal(Morgan and Yeung 2007). The literature on power sector regulation follows two strands in the form of price regulations and supervision and how they impact on electricity security. The electricity market design is an explicitly created regulation consisting of legally defined rules for the allocation, remuneration and the assignment of individual rights and obligations (Batlle and Rodilla 2010). In theory, a change in the formal regulatory system can initiate a behavioural change in the market if specific cost-benefit ratios are restructured. Again the economic theory of any contract regulation will have a substantive and institutional aspect. The substantive aspect asks what the state should do, while the institutional aspect asks which legal institutions should perform the necessary regulatory tasks (Schwartz 2000).

While law and economics scholars have proposed five regulatory functions for inter-firm contracts namely: enforcing a contract's verifiable terms; supplying vocabularies; interpreting agreements; supplying default rules; and regulating the contracting process, the competing theory of contract regulation stresses that the state should enact rules that are fair and that promote community among contracting parties (Schwartz 2000). The state is expected to supply parties with governance modes for the conduct of transactions or the resolution of disputes (Schwartz 2000). Given the constraints facing legislatures which limit their ability to implement ex post efficient or fair solutions (these functions should be performed for institutional reasons); that is, the limited competencies of legal institutions, imply that the state should not alter the performances that contracts require to achieve either ex post efficiency or ex post fairness (Schwartz 2000). In power markets, the underlying contractual regulation calls for the introduction of capacity mechanisms as a means to secure future supply (Batlle and Rodilla 2010).

From the time dimension perspective, the security of supply at the generation level can be decoupled into four major components (Batlle and Rodilla 2010). Breaking down the central problem into its sub-problems facilitates not only its understanding but also the design of a regulatory mechanism (if required). These components (or dimensions) are security, firmness, adequacy and strategic expansion policy (Batlle and Rodilla 2010).

Batlle and Rodilla (2010) define security, as a very short-term issue as the ability of the electrical system to support unexpected disturbances such as electrical short circuits or unexpected loss of components of the system (North American Electricity Reliability Council 1997).

Firmness, a short-to medium- term issue, defined in Batlle et al (2007) as the ability of the already installed facilities to supply electricity efficiently. This dimension is conditioned by the characteristics of the existing generation portfolio and the medium-term resource-management decisions of the generators (fuel provision and water reservoir management, maintenance scheduling, etc.).

Adequacy, a long-term issue, is defined as the existence of enough available generation capability, both installed and/or expected to be installed, to meet efficiently demand in the long term. Strategic expansion policy, they argued concerns the very long-term availability of energy resources and infrastructures. This dimension usually entails the diversification of the fuel provision and the technology mix of generation.

There is a certain consensus around the idea that, on one extreme, the security dimension can be tackled by means of operation reserves markets by taking into account the interaction between reserves requirement and the long term signals (Soft 2002), where the requirements are prescribed by the system operator. On the other hand, the strategic expansion policy has to be solved through the implementation of additional ‘‘out-of-the-market’’ mechanisms (e.g. feed-in tariffs or cap and trade mechanisms). But in between these two dimensions, the debate on the necessity of intervening to ensure firmness and adequacy (particularly this latter) has always been, and still is, quite intense (Batlle and Rodilla 2010).

An important aspect of security of supply concerns networks. Network infrastructure is essential to deliver energy supplies to customers, and comprises electricity wires and gas and oil pipelines. Empirically network companies' investments to interconnect to create an optimal network, such that supply can meet demand had not been without bottlenecks. Therefore most energy infrastructures have been built with some form of government involvement. In the UK for example, the natural gas network was built by the Gas Council and then British Gas in the 1970s and the electricity grid by the Central Electricity Board (CEB) before the war and developed by the Central Electricity Generating Board (CEGB) thereafter. In each case, a statutory monopoly, under public ownership, planned and developed the infrastructure (Helm 2002).

In the private sector, monopoly licences have been granted, supported by a regulatory duty to ensure that the functions of these companies can be financed, typically implying some guarantee to the regulatory asset base. It is notable, too, that electricity network capacity and interconnection problems have arisen in the European and Californian markets (Roques 2008).

The reasons for this government intervention are threefold: First, as natural monopolies, optimal networks based on marginal cost pricing will result in losses. Marginal costs are below average costs in the relevant range of output. Since monopolists cannot be left to set prices, investment in sunk network assets will always be at the mercy of regulators and governments. Government therefore has to commit to investors that the investment costs will be recovered (or do it themselves through public ownership). Second, where networks are owned within vertically integrated structures, regional incumbents have little incentive to invite competitors into their markets, nor to provide capacity sufficient to facilitate access for upstream rivals.

Third, in the absence of storage at the point of consumption, networks need excess capacity to absorb demand shocks. This aspect is a system property, where the public interest is represented as risk aversion to interruptions (in part because of complementarity), the capacity margin will need to be supported by regulation, to recover its costs.

It has also been suggested that network maintenance may not be optimally provided without regulatory intervention. This problem may arise under price-cap regulation, where output failures can only be observed with a lag or where shareholders are risk-neutral to shocks (such as severe weather), whereas customers are risk-averse. Again, this is a regulatory problem which may be exacerbated by management failure (as arguably in rail) or short-term ownership (as in the UK regional electricity companies (RECs)).

Competition in supply requires very considerable information technology systems, extensive metering and contract-risk management (Helm 2002). Rious et al (2015) show that regulatory penalties and the three tools: a generator's own capacity; the long –term contracts it has with other producers in the area of its integrated system operators (ISOs); and some capacity rights that it may acquire or exchange on a dedicated capacity market have combined to cure effectively the infancy problems. These penalties and tools have proved to be effective when the market is mature.

The next sections discuss the planks of regulatory structures and their relationship with electricity security of supply starting with market entry.

3.3.0 ENTRY AND ELECTRICITY SECURITY OF SUPPLY

The literature on entry into the power market value chain follows two strands. The first considers entry from the generation mix perspective. This means from highly carbonised sources to low carbonisation. The theories of costs which relate to environmental and generation sustainability are used to explain the economic justification from the shift towards a low carbonised regime. The full impact of the generation from coal and fossil fuel balances with the cost of using wind and sunlight which have no input costs.

The second strand of literature relates to deregulation and liberalisation of the power market itself which traditionally had been structured as vertically integrated industry. The benefits of economies of scale and scope provide the justification which additional factors such as capital requirement in developing countries.

3.3.1 THEORETICAL LITERATURE

One school of thought in support of the first strand of literature looks at this diversity of including gas and renewables in the generation mix from the portfolio theory (Vagliasindi and Basant –Jones 2013). The natural way to think about diversity is as a portfolio effect. Risks are spread in financial markets by diversification, and so too, the argument goes, by diversifying fuel sources. All the main fuel sources have claimed priority on diversity grounds and diversity has in practice proved a rationale for wider political objectives.

Governments have traditionally argued that diversity is best achieved by having a mix of fuel sources and by a preference for domestic over imported energy supplies. These may conflict- for example, the UK relied overwhelmingly on domestically supplied coal-fired generation, and France on nuclear, so that both countries had a very limited fuel mix. In practice, all sorts of policies have been justified in the name of diversity –for example, maintaining nuclear; expanding gas; supporting coal; and renewables (IEA 2016; Castro 2017).

But governments usually have a mix of objectives that determine the selection of, for example, renewables or nuclear that goes beyond CO2 emissions. Government policy is seeing the rejection or phasing out of nuclear power in a number of countries. Some countries would also prefer to reduce reliance on gas because it is imported or exposes consumers to long-term gas price risk.

Other countries are pro-solar. It should be acknowledged that, to a certain extent, major decisions about the generation mix remain a matter of state energy policy (IEA 2016), which can create an unstable environment for investment in supply infrastructure and can potentially amplify the risk to the security of supply (Castro 2017).

The second strand of literature follows the theory relating to contracts, contracting incentives and electricity security of supply. The theory suggests that willing buyers and willing sellers, left to their own devices, will seek mutually supporting contracts, assigning risk according to the relative values they place on it and their relative costs in bearing it (Glanchant et al 2013). In energy markets, spot trading brings the market into instantaneous balance, and the future profile of expected spot prices (the futures market) enables contracting to hedge the price risk. Complications arise where storage is possible, but electricity is essentially non-storable, and gas relies heavily on interruptible contracts with industrial customers and load variance from various consumers with varying gas production fields if any. A crucial fact for energy policy is that transparent, liquid futures markets do not exist for anything like the timeframe over which price risk may need to be hedged.

D'Aertrycke et al (2017) present a stylised model which discusses incomplete risk trading and its impact on investment. The analysis applies computable stochastic equilibrium models on a simple market model of the energy only type. They compare the cases of complete and fully incomplete markets (full risk trading and no risk trading) and test the impact of different risk trading contracts on both welfare and investment.

In contrast with most of the literature, their analyses show the impact of long-term demand risk on investment in energy only markets (EOM) where the missing money is corrected by a price cap. Taking stock of that basic framework they add risk mitigation instruments such as long-term contracts (contracts for differences (CfD), reliability options (RO) or forward capacity markets (FCM)) under different assumptions of market liquidity.

Long term contracts in liquid markets and very well calibrated FCM are very effective in reducing hurdle rates and hence favour investment. But contracts are vulnerable to liquidity and FCM to calibration. All the mechanisms are originally designed to solve the missing money problem and are extensively analysed for a deterministic setting. In their stochastic setting, it turns out that different proposals perform very differently and might even fail to provide a much improved outcome (as long as liquidity might not be there). They find that adding an FCM to the EOM can have quite different effects depending on how the demand for capacity is calibrated. A bad calibration entails a significant loss of investment and welfare.

This leads to a very simple policy implication: risk can seriously damage the effect of remedies to insufficient investment. The deterministic and complete risky markets are non-ambiguous paradigms that lead to clearly defined analysis. Incomplete markets form a whole spectrum of situations that each needs to be studied individually, most often by numerical simulations. It is thus of the essence not to unnecessarily add risk. Some risks are exogenous and unavoidable. The other is internally generated by the policy and should be avoided. Compensating for this risk by trading is difficult and may not give the intended effects. One should also be wary of measures that “boost” some instrument without a full argumentation of their efficiency. Also, measures may be difficult to calibrate.

While D’Aertrycke et al(2017) took a quantitative approach, the other strands of literature using qualitative approaches present two opposed strategies: do nothing or market-led paradigm and capacity markets (Batlle and Rodilla 2010; Hawker et al 2017).

Under the market-led paradigm, spot markets for electricity should provide a complete price signal for sufficient investment in new generation capacity. If there is a perceived shortfall in capacity at some future horizon, it should also be evident to investors that there is a matched benefit in owning operating capacity at that point in time due to raised electricity prices reflecting that shortfall– in other words, scarcity pricing should stimulate new investment. Hawker et al(2017) raise the ‘missing money’ problem which occurs, when conditions arise in markets which mean that the energy market alone does not provide sufficient (or sufficiently reliable) revenue for investment to occur. In keeping with Newbery (2015), this may arise due to a number of factors, including: low wholesale energy prices (which may be driven by high penetrations of renewable generation with negligible marginal costs); price caps below the value of lost load (the economic cost impact of not supplying a consumer with their desired power demand); inefficiently high transmission charging; or inadequate remuneration for ancillary services. Tangeràs (2018) cites Cramton et al (2013) and Hogan(2013) and supports their views that there may be the ‘missing market’ problem in electricity markets and more challenging is where the revenue is in reality adequate but is not perceived to be so (Newbery 1989). This is because the value of lost load (VOLL) is difficult to estimate correctly (Tangeràs 2018). Again, it may be politically infeasible to permit the electricity price to increase by a factor of 100 or more above its level to achieve VOLL (Cramton et al 2013; Tangeràs 2018). VOLL represents the willingness of consumers to pay to avoid supply shortfall. In the UK, VOLL was estimated around £5,000/MWh at the end of the Power Pool of England and Wales in 2001 and according to London Economics (2013) as cited in Castro (2017) is estimated at £17,000/MWh.

Do something on behalf of the demand; in the opposite belief. In this case, the regulator designs a security of supply mechanism which entails the definition of a certain reliability-oriented product (the ‘‘reliability product’’) aimed to ensure system security of supply (i.e. avoid scarcities). This reliability product is provided by the generators, who receive in exchange the extra income or the hedging instruments they require to both proceed with efficient investments (adequacy) and make resources available when most needed (firmness).The other counterparty is either directly the demand, compelled to purchase the product by the regulator, or the regulator itself (i.e. the system, the tariff) acting on behalf of the demand. If the regulator opts for this alternative, there are several key elements of the mechanism that have to be carefully designed to avoid inefficiencies (Batlle and Rodilla 2010; Rious et al 2015; Ang et al 2016).

Batlle and Rodilla (2010) argue that, capacity payments are a form of a price-based incentive mechanism, that seek to achieve both an efficient resource management (firmness) and investment (adequacy and strategy energy policy). The mechanism entails mainly two problems: first, to properly define the reliability product, second, to fix the price (right enough to avoid falling too short or too long) if used as part of the demand response program in a jurisdiction (Rious et al 2015).

Under quantity mechanisms, the regulator imposes on (or buys itself on behalf of) the demand the purchase of a specific quantity of the reliability product. In this context, this product takes a variety of formats, e.g. an energy long-term forward or a capacity credit, etc. Depending on the system, the product may be traded bilaterally, within an auction (centralised or not) or by means of additional and organised short-term markets (Batlle and Rodilla 2010).

In the price-based mechanisms context, the product is usually the so-called firm capacity. Each unit's firm capacity is aimed to represent the unit's contribution to the overall system's security of supply. In practice, depending on the system, we find many different alternative methodologies to define the firm capacity. In most of the cases it is mainly based on the (expected) availability of each generating unit when most needed, but sometimes other parameters are used in its calculation as for instance the units' variable costs (e.g. the smaller the variable costs, the larger the firm capacity assigned, as for example it is the case in Guatemala, Ireland or Brazil) (Batlle and Rodilla 2010).

3.3.2 EMPIRICAL LITERATURE

The IEA (2016:24) study of deregulation shows that there exists some varying degree of competition globally. The IEA study suggests that different counties have different electricity systems and objectives, which shape the organisation of their markets. The effect of deregulation on electricity security of supply has been mixed. In Europe, market coupling has been used as a method for integrating electricity markets across different areas (Glachant et al 2013). In 2014, full price coupling in the South Western Europe (SWE) and North Western Europe (NEW) day-ahead electricity markets was achieved (Glachant and Ruester 2014).

In California, after the California energy crisis of 2001(Joskow 2001), regulatory framework failures have enabled ENRON to manipulate the electricity market, which ultimately caused involuntary load curtailment that imposed high cost on consumers (Joskow 2001).

Similarly, Brazil liberalised its system in the 1990s, but the new market did not attract adequate investment. Faced with one of the most serious energy crises in history in 2001-2002, in a context of drought, Brazil resorted to developing an integrated long term plan for the power sector (Pinguelli et al 2013). The crisis originated from insufficient hydropower generation during drier years, delays in the commissioning of new generation plants and transmission issues (Pinguelli et al 2013).

Finally, in the United Kingdom, recent electricity market reform also marked a step toward a higher degree of regulation (Newbery 2012). A capacity market was introduced to ensure adequate reliable capacity, while Contracts for Difference (CfD) were introduced to replace the more market-based green certificate scheme and to support investment in nuclear energy (Newbery 2012).

According to IEA (2016) the initial goal of creating larger markets and promoting trade in electricity to reduce overall costs of power systems has been achieved. Empirically, the trade in electricity has increased in North America and Europe. In addition, restructuring is also associated with increases in operating efficiency (Davis and Wolfram 2012) achieved primarily by reducing the frequency and duration of plant outages (Davis and Wolfram 2012).

More importantly, it has triggered a wave of investment in gas-fired power plants, influenced by factors which include the relatively short construction time, the decline in wholesale gas prices and the desire by regional electricity companies to diversify sources. For example with the UK's dash –for gas in the 1990s, the share of combined cycle gas turbine to its generation capacity has increased from 4.5 per cent to 30.9 per cent in 2002(IEA 2016).

3.3.3 CRITIQUE OF LITERATURE

The literature does not provide details of the costs and managerial resources needed by developing countries to develop their optimum generation mix and transition their power markets that are critically based on the liquidity of the market (D'Aertrycke et al 2017). In theory, an electricity market based on the sale of electrical energy in megawatt hours (MWh) (energy-only market (EOM)) combined with a sufficiently high carbon price could plausibly ensure decarbonisation in the long term. As usual in economic theory, a set of assumptions has to be satisfied, including perfect correction of externalities, separation of efficiency and equity/distributive objectives, convexity of cost functions and perfect competition. In practice however, these assumptions do not all hold and consequently market-based low-carbon investments face a number of challenges in both developed and developing countries (IEA 2016). In electricity and gas, futures markets are even weaker, while, at the extreme, nuclear stations and hydro dams have project lives of up to half a century (or sometimes more), and even gas CCGTs can be decade-long projects. Although some claim that such futures markets will develop, the fact is that, for current investment projects, and current long-term take-or-pay contracts, they do not remotely cover the time period. Therefore, there is a core contracting problem in energy markets which policy needs to address (Joskow 2007).

Furthermore, the assumptions which give rise to variations in measuring the contribution of firms to electricity security of supply under a price-based mechanism where the product is the firm's capacity do not hold in capacity short economies. Availability is the most important factor (Best and Burke 2018) and it is also due to socio-political reasons. Although Roques and Finon (2017) make an important contribution to the literature with their suggestion that a two-step competition leading to a hybrid system appears appropriate but the literature is scarce on the sequencing, effective monitoring mechanisms to be instituted in the reform process and the impact of such measures on affordability in capacity short economies. The literature on mechanisms such as the auctioning of market demand and concession propositions also have their limitations as they do not explain why potential participation appear to be limited in Sub-Saharan Africa except for known factors such as the high level of political and regulatory risks (Eberhard et al 2017).

Table 3.1a Summary of the Literature on Entry or Deregulation and Liberalisation and Electricity Security of Supply (ESoS)

Author (Year)	Study Period	Sample size	Methodology	Electricity Security variable	Summary results
Batlle and Rodilla(2010)	2010	Cross-country capacity markets – Europe, Americas	Comparative and Normative	Electricity Security of Supply (ESoS)	The vast majority of problems have not arisen because of the liberalisation, but because of the poorly designed regulation.
Cox, M.(2016)	2016	25 Experts from the UK	Semi –Structured Interview	Electricity Security of Supply (ESoS)	There is a real need to attempt to take into account multiple competing and context specific views on energy security, instead of trying to close down around a small number of simple quantifiable indicators or metrics.
Larsen et al(2017)	2012	Single jurisdictional model	Comparative and Normative	Electricity Security of Supply (ESoS)	Security of supply need not be one dimensional but on a multitude of dimensions simultaneously.
Osorio et al (2017)	2017	Single jurisdictional model	Cross-impact Analysis	Electricity Security of Supply (ESoS).	Proposed 12 dimension to evaluate ESoS for a single jurisdiction. However, actions at improving one dimension might impact others negatively. Understanding their interrelationship is a prerequisite for appropriate planning and resource allocation.
Vagliasindi and Besant – Jones(2013)	2013	22 countries from 6 developing country regions	Fixed and Random Effects Analysis	Electricity Security of Supply variables (4As)	Vertical unbundling is positively and significantly associated with better performance. Disaggregation in generation is also positively and significantly associated with better performance, with the exception of labour productivity.

Table 3.1b Summary of the Literature on Entry or Deregulation and Liberalisation and Electricity Security of Supply (ESoS)

Author (Year)	Study Period	Sample size	Methodology	Electricity Security of Supply variable	Summary results
Hawker et al(2017)	2004-2016	EU Countries	Comparative and Normative	Electricity Security of supply (ESoS)	National Capacity Markets ensure the security of electricity within each EU member own borders. The to-date regional view of electricity security prefers on-going self-sufficiency over mutual security, even though this comes at a greater cost.
Petitet et al (2017)	2017	EU Countries	System Dynamic Model	Electricity Security of Supply (ESoS)	The energy-only market design with a price cap, with and without a capacity mechanism, is compared to scarcity pricing in two investment behaviour scenarios with and without risk aversion. The results show that the three market designs lead to different levels of risk for peaking unit investment and results thus differ according to which risk aversion hypothesis is adopted. Assuming a risk-neutral investor, the results indicate that compared to an energy-only market with a price cap at 3 000 €/MWh, an energy-only market with scarcity pricing and the market design with a capacity mechanism are two efficient options to reach similar levels of load loss. But under the hypothesis of risk aversion, the results highlight the advantage of the capacity mechanism over scarcity pricing.
Roques and Finon (2017)	2002 -2016	3 Countries- Brazil; Chile; UK.	Comparative and Normative	Electricity Security of Supply (ESoS)	Market architectures could converge toward a hybrid regime structured around a "two step competition", with a "competition for the market" via the auctioning of long-term contracts to support investment, followed by "competition in the market" for short term system optimisation via the energy market.

Table 3.1c: Summary of literature on Entry or Deregulation and Liberalisation and Electricity Security of Supply (ESoS)

Author (Year)	Study Period	Sample size	Methodology	Bank risk-taking variable	Summary results
Spalding-Fetcher et al (2017)	2010-2070	12 countries forming the SADC and the SAPP	LEAP Model	Electricity Security of Supply and Demand	There has been recent inroads from gas-fired power in the SAPP. The potential transformation of the supply sector from coal-fired plants to renewable and less carbonisation in electricity generation require fundamental shifts in resource use, grid management and infrastructure development.
D'Aertrycke et al(2017)	2017	1market type	Reduced Model – Stochastic Equilibrium Models	Electricity Security of Supply(ESoS)	Risk, risk aversion and the extent of risk trading drastically impact investment in energy only market (EOM.) They find that these contracts are quite effective complements to EOM. They also find that adding a Forward Capacity Market (FCM) to the EOM can have quite different effects depending on how the demand for capacity is calibrated. A bad calibration entails a significant loss of investment and welfare. But these instruments bring their own risk. They find that both the Contracts for Differences (CfD) and Reliability options (RO) may require trade volumes never encountered so far in power markets.

3.4.0 POWER SECTOR GOVERNANCE AND ELECTRICITY SECURITY OF SUPPLY

Energy governance is a highly context-dependent and is defined as a process of co-ordination in which institutional properties (system of rules, policies) and interdependent (public-private) actor constellations interact to decide how to provide energy service (Zaman and Brudermann 2018). From the perspective of resource law and policy governance, it is understood as the system which manages and allocates resources. The theory relating to resource law and policy focuses on transparency as the fundamental tool to manage the resources in any social setting (Heffron and Talus 2016a).

Transparency is based on the premise that the government occupies the highest point within the hierarchy and has institutions to capture the rent from the resources with proper reporting and disclosure procedure and processes. These activities are backed by the necessary legislation with the role of regulation to ensure implementation and enforce compliance. Advocates of greater transparency argue that it provides safeguards against many of the powerful incentives for corruption, such as high entry costs, the multiplicity of parties involved, the technological complexity of resource development, complex revenue accounting, and traditions of sector secrecy.

Transparency and accountability are now thought to be critical to combat these and permit the efficient and prudent management of natural resources and their revenues throughout the extractive industry (EI) value chain. Therefore, the political process of setting ambition levels must not be part of the governance regulation. Failing to observe this separation of tasks, would compromise the potential of the governance regulation to act as a coherence and policy streamlining tool (Cameron and Stanley 2017).

The term stakeholder is relative to the issue; it is time and site specific, which means a stakeholder’s relevance, may change over time and between issues. Stakeholders are the players who may have entitlements by their constitutional rights or other means of exercising their societal rights or interests (Johnson et al 2011). Stakeholder interests can range from government to energy consumers and not exclude the energy companies, their investor and employees. The rules and incentives are the cognitive routines and shared beliefs, capabilities and competences, lifestyles and user practices, favourable institutional arrangements and regulations, and legally binding contracts which relate in the electricity system (Geels 2011). The rules and incentives that are shaped by the stakeholders also have a role in shaping the stakeholders, making governance a fluid concept.

The above hierarchical system is different from the market –based system where the market determines the allocation of resources and the government facilitates the smooth operations of the market to optimise its efficiency. This variation in governance dominates energy law and policy which focuses on markets and government’s facilitative role. The governance design of centralised and decentralised approaches can be observed in many jurisdictions depending on the availability of capital and maturity of the energy market.

Williamson (1996) suggests that there is a spectrum of mechanisms to govern a transaction and that there is a best alternative for every discrete combination of transaction attributes. The market- based governance mechanisms include: spot market, specification contracts, relation-based alliances, equity –based alliances, and vertical integration (Peterson et al 2001).

Energy governance from the agency and property theories refers to the implicit and explicit contractual relationships influencing the incentives of energy managers and policy makers. In corporate governance literature it is usually assumed that managers in a good governance system maximise shareholders wealth while the incentives to serve the interest of other stakeholders are provided by market forces, law, and regulation (Edomah et al 2017). The various ownership structures lead to differences in how the purposes of an organisation are shaped and how strategies are developed as well as the role and composition of boards (Johnson et al 2011).

3.4.1 THEORETICAL LITERATURE

Economists for a long time used to assume without question that players that make up modern corporations such as managers, employees, shareholders and bondholders acted for the common good but recent experience over the past 30 years shows that there are conflicts of interests (Brealey et al 2008). In addition, the property rights theory and legal approach to finance affirm that shareholders are the rightful owners of modern listed firms (Marcelin and Mathur 2015) whereas agency theory posits that managers are agents of shareholders (principals) that run the firm on their behalf (Brealey et al 2011). However, gas-to-power literature on governance and electricity security of supply (Eberhard et al 2016) indicate that there are conflicts between shareholders and policy makers, where it is hypothesised that managers and policy makers diverge shareholders interest and reduce and / or appropriate the shareholders' wealth unless there is alignment of reward which allows managers to share the gains from the risky projects with the shareholders. Such divergence may arise from missing money, poor lag in the contractual period allowed for hydro projects which need a longer time to complete as against gas-fired projects among others. In the power sector, this is the well-known principal-agency problem within many state owned firms (Jensen and Meckling 1976; Eberhard et al 2017), investor –host country conflict of interest (Phadke 2009 and Kashi 2015).

Empirical studies of organisational structure and governance strategies often apply transaction cost economics (TCE) theory to guide the analysis. The TCE framework indicates that four underlying attributes of a transaction (i.e., asset specificity, uncertainty, complexity, frequency) must be taken into account if trading parties seek to implement the most efficient governance strategy to coordinate transactions (Williamson 1985, 1996). Williamson identifies four types of governance structures to regulate contractual arrangements: market, exogenous, endogenous and unified. In the market governance, the specific identity of the parties is of negligible importance, substantive content is determined by reference to formal terms of the contract, and legal rules apply. Market alternatives are mainly what protect each party against opportunism by his opposite. Litigation is strictly by settling claims and concentrated efforts to sustain the relation are not made, because the relation is not independently valued. Market governance structures emphasize the discrete nature of the transaction and enhance presentation.

More complex governance structures emerge in response to the need for long term arrangement and uncertainty. Long term contracts are characterised by the existence of gaps in planning and the presence of a range of techniques to create flexibility in lieu of leaving gaps. According to Macneil (2000), long term contracts are typically regulated by either of two governance structures: exogenous governance whereby state contractual guarantees are legally enforced by the government or some other outside institution; and endogenous governance whereby an implicit contractual guarantee is enforced by market mechanism of withdrawing future business if opportunistic behaviour occurs. Other factors related to the decision of governance choice include implementability (Peterson et al 2001), the reputation (Masten1996), and trust (Gulati 1995) of the exchange partners.

Signorini et al (2017) show that the implementability of the governance structure and the reputation of trading parties, two complementary concepts, are important factors to explain the distinction between adopted and predicted governance strategies. Peterson et al (2001) argue that the existence of an efficient governance strategy does not ensure its implementability. In the authors' view, an efficient strategy can only be implemented if a set of four conditions are jointly met: (i) decision makers have the capital required to implement the strategy; (ii) decision makers have trading partners with desirable characteristics to meet the needs of the strategy to be implemented; (iii) decision makers are capable of exercising the type of control required by the new strategy; and (iv) the strategy is legal and does not violate the current institutional framework. Reputation, the second concept, might curb opportunistic behaviour in some circumstances and guide firms towards less integrated governance strategies (Signorini et al 2015).

As Masten (1996) puts it, ‘reputation may deter opportunism if counterparties can observe occurrence and have alternatives for future transactions’. However, some scholars have questioned whether TCE is the most appropriate theory to predict optimal governance structures (Kim and Mahoney 2005). Others have found that TCE is insufficient to explain why businesses in the same complex industry adopt different governance strategies to support exchange and yet both strategies could be efficient alternatives (Delmas and Tokat 2005).

Erdogdu (2013) extends the argument by drawing our attention to the new institution economics which ties in with transactions cost theory from six angles. New Institutional Economics (NIE) contributes to the analysis of power sector reforms in multiple ways. First of all, NIE underlines that institutions matter for any economic reform and electricity market reform is not an exception. In essence, electricity market reform is an institutional reform that necessitates de facto or de jure regime change, the creation of new institutional structures and rearrangement or removal of existing ones. Institutions may determine the divergent patterns of evolution of reform processes in various countries over time. In the literature, the relationship between institutions and economic transformations has been investigated by many scholars including Atems and Hotaling (2018); Yao et al (2018) and Zaman and Brudermann (2018).

Second, while analysing reforms in electricity markets, the standard neoclassical assumptions that we have perfect information and unbounded rationality and that transactions are costless and instantaneous should be abandoned. NIE implies that information during the whole reform process is rarely complete, and transactions related to the reform process have costs associated with them, such as costs of finding out what and how to reform, of negotiating the reform direction with interested parties, of passing necessary legislation, and then of monitoring and enforcing it(Erdogdu 2013).

The third contribution of NIE is its suggestion that reformers should see institutions as a means of reducing information and transaction costs related to reform design and implementation; and never forget that institutions may easily turn into critical constraints on reform performance if not taken into account properly. Fourth, NIE maintains that there is a fundamental relationship between property rights, transaction costs and institutions. When property rights are not clearly defined in the course of an electricity market reform, transaction costs increase and reforms may fail (Erdogdu 2013).

The fifth advice from NIE for electricity market reform is that policy makers should pay due attention to non-market transaction costs faced by the firms in the market and do their best to eliminate or, at least, minimise them. The sixth repercussion of NIE relevant to electricity reform is that the process of electricity market reform is largely path dependent, which may explain why some countries succeed and others do not in reforming their power sectors. So, getting the institutions right is critical to reform success as getting them wrong can lead to path-dependency, whereby inefficient electricity markets may persist (Erdogdu 2013).

So, to prevent inefficient institutional structures in the subsequent reform phases, the utmost attention should be paid to arrangements at the very beginning of the reform programs (Erdogdu 2013, 2014; Di Bella and Grigoli 2017). The right people should set up the right structures (Erdogdu 2013; Banal- Estaňol et al 2017; Di Bella and Grigoli 2017).

3.4.2 EMPIRICAL LITERATURE

In light of these criticisms, Signorini et al (2015) examined the governance strategies adopted by power generating firms and final consumers in Brazil's renovated electricity market. The Brazilian electricity sector provides a particularly interesting environment for this analysis for two reasons. First, the financial stimuli (e.g., tax incentives, favourable loans) offered to generators and consumers of clean energy helped Brazil solve imbalance problems while diversifying its energy mix, and consequently mitigating emissions of green house gases (GHGs). Second, the Electricity Sector Reform (1995–1998) and subsequent amendments established two trading channels — one for regulated transactions and the other dedicated to unregulated transactions between independent consumers or special consumers and generating firms. They focused specifically on transactions conducted in the unregulated channel as parties in this channel are authorised to freely choose governance strategies. The same cannot be stated for transactions conducted in the regulated channel. Put differently, the Brazilian electricity market characterises a rich setting for analysing how firms choose governance strategies, where conventional and renewable energy generators integrate the supply side of the industry. The results were mixed. They show that the transactions cost efficiency theory is an elegant qualitative framework for predicting transaction efficiency, has also shown its inability to explain how firms decide over governance strategies. Its effectiveness is enhanced when complemented with implementability and reputation.

Further empirical evidence of governance through transaction costs economies is seen from the fuel input sector for power generation in liquefied gas sales and projects by Ruester (2009; 2015). She showed a negative relationship between transaction costs and LNG sales and project financing. Minimisation of transaction costs which leads to long term contracts has positive effects of increasing fuel input projects for potential electricity generation. This is very relevant for a resource –rich developing and maturing electricity market where the governance of the value chain requires an integrated structure to secure the gas resources for power generation.

Edomah et al (2017) examined the energy governance in Nigeria and how policy making impact on energy infrastructure which affects electricity security of supply. They concluded that the definition of governance nexus is important to prevent unintended consequences like lack of energy security. They cite Bray (2015) that across many countries in Africa, with around 60% of the countries classified as being highly corrupt, has made their power sectors less dynamic and complex.

Zaman and Brudermann (2018) examined the energy governance in the context of energy service security in Bangladesh over the past 10 years in which the assessment of the electricity system was the central theme. Their findings indicate the presence of weak institutions in the electricity sector, a lack of market competition and the need for consistent policy implementation and proper pricing and information disclosure mechanisms. In addition, other challenges such as endemic corruption and bureaucratic complexities, underdeveloped grids and insufficient resource logistics also need to be addressed. They also identified the existence stakeholder conflicts in the energy sector from the fact that while international interventions and national policies favor a heavy take-up of fossil fuels in order to achieve energy security and energy equity, environmental sustainability is largely ignored. The study shows that the integration of energy governance and energy security perspectives is crucial to understanding and addressing the challenges of a just energy transition in the face of the standard energy trilemma in developing countries.

3.4.3 CRITICAL REVIEW OF THE LITERATURE ON GOVERNANCE MODEL AND ELECTRICITY SECURITY OF SUPPLY (ESoS)

Table 3.5 presents some empirical literature work on energy governance and electricity security of supply. The literature does not analyse the impact of management structures on electricity security of supply. Again the literature is skewed towards the use of the qualitative approach in analysing the impact of governance on electricity security of supply in developing countries.

Again the literature is silent on how the various roles of board members affect electricity security of supply. Furthermore, the literature is largely limited to power sector performance with few examining how and through which channel specific governance structures and observable board characteristics influence electricity security of supply particularly in Sub–Saharan Africa.

The literature also needs to be expanded to bridge the gap between he instrumental economic analysis of law that is rationally designed to correct market imperfections and the plural –disciplinary and historical analysis of institutions(Deakin et al 2017), with particular attention to 'legal pluralism' or diversity (Prévost and Rivaud 2018).

Table 3.2 Summary of the literature on Governance and Electricity Security of Supply(ESoS)

Author (Year)	**Study Period**	**Sample size**	**Methodology**	**Electricity Security variable**	**Summary results**
Reuster,S.(2009)	2009	224 Long term contracts	Regression Analysis	LNG for power market	She finds a statistically significant negative effect on contract duration of three variables measuring repeated interaction between contracting parties. These are the number of contract renegotiations, the number of years of the contract and the extension of previously struck contracts.
Reuster , S.(2015)	2015	26 Liquefied Natural Gas export and import projects	Regression Analysis	LNG project financing	Lenders will make their decision on how much to lend depend on the risk profile of the project in this vein , a project 's off-take agreement serve as a security for financial contracts.
Eberhard et al (2016)	2016	Power sector governance	Normative	Electricity Security of supply	Public control leads to inefficiencies in the power sector in many Sub-Saharan countries.
Edomah et al(2017)	2017	8 Nigerian institutions	Semi-structured interview	Electricity Security of supply	The definition of energy infrastructure and governance nexus are critical to prevent the generally poor state of the Nigerian power systems.
Signorini(2017)	1994-2015	3 segmented Brazilian power groups	Qualitative analysis	Electricity Security of supply	The TCE framework might gain consistency in explaining why trading parties sometimes adopt perceived less efficient strategies if implementability and reputation are taken into consideration.

3.5.0 ACCOUNTING AND ELECTRCITY SECURITY OF SUPPLY

Accounting for power in its value chain has implications on electricity security of supply. Electricity markets are characterised by very long investment cycles, both in terms of cost calculations for new investments as well as the break-even point of energy infrastructure investments. Conventional electricity generation capacities are also characterised by high fixed costs and high dismantling costs. Unused power plants cannot be easily used for other purposes or shipped elsewhere and are therefore typically characterized by high opportunity costs of a low utilisation rate (Ellenbeck et al 2015).

The levelised cost of electricity (LCOE) is a commonly used metric for comparing different generation types. Typically expressed on a $/kWh basis, it is the estimated amount of money that it takes for a particular electricity generation plant to produce a kWh of electricity over its expected lifetime. LCOE offers several advantages as a cost metric, such as its ability to normalise costs into a consistent format across decades and technology types. Consequently, it has become the de facto standard for cost comparisons among the general public and many stakeholders such as policymakers, analysts, and advocacy groups (Rhodes et al 2017). There are many organisations that calculate LCOE values either for each year, future projections (Parsons 2017), or for specific clients (Rhodes et al 2017).

Despite its advantages and widespread use, the conventional LCOE has several shortcomings that render it spatially and temporally static. Costs of building and operating an identical plant across different geographies will be different. Moreover, fuel costs, capacity factors and financing terms will differ across regions as well. However, LCOE does not readily incorporate these differences. LCOE can also be problematic because of the assumption of constant capacity factors over the lifetime of the plant. Furthermore, the LCOE framework does not anticipate real-time prices or market behaviours, and therefore is more suitable for base load analysis for average conditions rather than for variable generators such as wind and solar (Joskow 2011). It is also difficult to project LCOE values into the future for fossil fuel and nuclear plants because of the uncertainty of future fuel costs, capacity factors, and regulation. In addition, there have been few attempts to incorporate the costs of environmental externalities into the framework (Cohon 2010; Epstein et al 2011; Wittenstein and Rothewll 2015).

The transmission of power also has accounting implications. The incorporation of network security in benchmarking analysis typically involves identifying the network security related 'inputs' (such as capital and operating expenditures of network security) and a range of network security-related 'outputs' (such as quality of service, e.g., duration and frequency of interruptions). A network company will then be regarded as being more efficient, in our case in delivering network security, if it is able to deliver more network security-related outputs while using less input factors (Nepal and Jamasb 2015).

Network utilities incur both operational expenditures (Opex) and capital expenditures (Capex) related to network security. Opex generally include operating and maintenance costs (both variable and fixed) that the network company incurs during a fiscal year. Capex generate long-term future benefits and are incurred when a network company invests in new fixed assets to replace the existing old assets or to expand the network. There are several ways in which these costs can be structured, aggregated and treated in a benchmarking exercise under an input-based incentive regulation. The method of recognising or analysing costs can be bottom –up or top-down**.** Nepal and Jamasb (2015) argue that the use of the bottom-up approach such as the partial cost benchmarking analysis can lead to an overall estimate of costs, which can be unfeasible, and an unreasonable basis for setting targets, as the regulator combines the most efficient (or the lowest) costs for each subset from different network companies (Shuttleworth 2005).

The top-down approach uses a comparison of total network security costs among network companies. The approach can involve controlling for the effects of contextual factors, such as economies of scale, scope and density and network topography (Nepal and Jamasb 2015). Benchmarking total expenditures (Totex) creates a more equal treatment of capital and operational expenditures in efficiency analysis, and is an alternative approach to overcoming the problems associated with the accounting treatment of capital expenditures. Moreover, an effective Totex benchmarking requires large datasets to minimise the aggregation problem as the transmission and distribution companies tend to invest in network security assets with a long service life. This is important, as network security Totex can constitute lumpy, indivisible, volatile and cyclical investments, which lead to wide short-term fluctuations in the annual value for Totex.

An alternative approach to Totex benchmarking is the total cost benchmarking. The total cost includes the sum of Opex plus the depreciation of capital and an allowed return on capital. Hence, total cost benchmarking, to some extent, addresses the challenges associated with capex benchmarking when investments are characterised by lumpiness and annual variability.

3.5.1 THEORETICAL LITERATURE

From a theory point of view, the optimum level of network security (and service quality) is attained when a profit maximising regulated company increases network security to the point where the marginal benefit of additional network security equals the companies' marginal cost of increasing security (Sappington 2005). In economic and benchmarking modelling terms cost drivers are explanatory factors that drive the costs of network companies. Hence, it is desirable that the incentive regulation and benchmarking models can also reflect the network security. The incorporation of network security variables directly within a benchmarking model as 'outputs' can provide incentives to deliver these outputs at different cost levels. This is especially relevant given the European regulatory concerns with investment inadequacy, innovation and sustainability. Incentive regulation is also changing from an input-based to an output-based approach in countries such as the UK and Italy (Cambini et al 2013). An output-oriented approach combines the efficiency mechanisms in a revenue cap framework with output-based incentives, including those concerning network security.

The primary cost drivers in network benchmarking can include demand and supply side variables, such as the number of connections (a proxy to reflect fixed costs), load served (a proxy for network capacity), volume of energy delivered (a proxy to reflect the cost of energy), network security variables, network energy losses and network length.

The selection of cost drivers should ideally be independent of data availability considerations. For example, Turvey (2006) criticised the practice of choosing the number of cost drivers to suit the data. The use of available data on electricity distributed (MWh) as a proxy for maximum demand and on network length per customer as the customer density variable to explain maximum demand can be questioned since they are only useful at the sub-station level. This is because if demand falls in one area, spare capacity cannot be 'physically relocated' to another area (Nepal and Jamasb 2015)**.**

On the other hand, the inclusion of network length as an output variable can introduce perverse incentives by encouraging network expansion solely to improve relative performance (CEPA 2003). Coelli (2012) suggests that one possible approach to choosing the relevant cost drivers is to explore the implications of an engineering-based reference or norm model of network companies. For example, Burns et al (2005) describe a method previously used in Austria for selecting cost drivers based primarily on an engineering-based simulation model of a hypothetical distribution network. Jamasb and Soderberg (2010) highlight the Network Performance Assessment Model (NPAM) previously used by energy regulators in Sweden, Spain, Peru and Chile.

However, network security is generally unexplored in benchmarking analysis, implying that the existence of a network security that defines the output indicator as a cost driver in benchmarking analysis is largely unknown.

The quality of service indicators that commonly enter the benchmarking models as explanatory variables are the continuity of supply indices, such as the System Average Interruption Duration Index (SAIDI) and the System Average Interruption Frequency Index (SAIFI). However, these indicators are generally inadequate for mimicking the impact of interruptions arising from exceptional events because exceptional events lead to long, unplanned interruptions (CEER 2012).

Hence, an alternative approach would be to construct a new SAIDI indicator that only accounts for unplanned interruptions of longer than 5 min (Nepal and Jamasb 2015). Long, unplanned interruption of at least 5 min (which are relatively more frequent than major exceptional events) can mimic the impact of interruptions engendered by exceptional events. Also, while there is limited data on exceptional events, more data is available on long, unplanned interruptions. Furthermore, it is advisable to use an average measure over several years instead of annual values as exceptional events that are less frequent than short and planned interruptions. This would increase the stability of the network security indicator.

For the transmission system reliability, other output indicators such as ‘unsupplied energy’ or average interruption time (AIT) can be used. For example, Ofgem developed incentive mechanisms for different aspects of distribution network service quality in 2004. For example, a new incentive mechanism in the UK introduced in 2005 focused on transmission system reliability as measured by the value of energy not supplied (Ofgem 2004).

However, consistent cross-sectional and time series data measuring different aspects of network security such as interruption statistics are generally not available, as network companies do not systematically report them. Improving data quality is possible when regulators are resourceful and invest the required time and effort.

3.5.2 EMPIRICAL LITERATURE

For example, the total cost approach to benchmarking has been adopted by the Dutch and Norwegian regulators in their regulation of transmission and distribution networks (Ajodhia et al 2006). Total cost benchmarking creates incentives to improve security performance in both the short and long run. However, determining a suitable basis for the depreciation of asset values (accounting, regulatory or economic) such as book values versus replacement costs, and calculating the return on capital can be problematic (Diewert 2005). Overall, costs benchmarking requires standardised definitions and classifications of Opex and Capex, considering the differences in accounting classifications of costs across countries (Cohen 2005). From a social-welfare perspective, a regulator can also consider incorporating the costs of inadequate network security in the total cost estimates and undertake benchmarking analysis based on a measure of the social costs of network security.

The Finish and Norwegian regulators have included the estimated socio-economic cost of outages (i.e., the value of energy not served due to outages) as part of the total cost for efficiency benchmarking (Kuosmanen 2012). Outage costs are also used as an instrument to evaluate the social cost of service, including service quality. However, there is no consistency in estimating outage costs among the EU regulators. Assessing the costs of network security failure can be contentious and the information requirement is high considering the multi-faceted and infrequent nature of the problem as well as the limitations on data availability and quality.

Some recent studies have examined the impact of quality of service regulation on the performance of network companies in terms of cost efficiency and quality provision using benchmarking analysis. Norway is a notable exception in integrating the cost of quality (in the form of the value of energy not delivered) in the efficiency benchmarking exercise. Growitsch et al. (2010) explored the impact of incorporating customers' willingness-to-pay for service quality in benchmarking models on the cost efficiency of distribution networks in Norway using the data envelopment analysis (DEA) technique. The results showed that the introduction of a service quality regulation had no conflict with and impact on the performance and cost efficiency of the network utilities. For example, empirical studies, such as Ter-Martirosyan and Kwoka (2010) have shown that in the absence of appropriate quality controls, incentive regulation leads to deteriorating levels of service quality in the US electricity networks.

In the UK electricity distribution, Jamasb et al (2012), by specifying a new empirical model, show that regulatory incentives to reduce service interruptions had not been sufficiently strong to achieve economically efficient levels of service quality. However, the economic incentives to encourage utilities to reduce network energy losses have led to performance improvements in this area.

Cambini et al. (2014) investigated the response of the largest Italian electricity distribution company to the input- and output-based incentives using a balanced panel for 115 companies spanning 2004–2009. A two-stage, semi-parametric data envelopment analysis (DEA) and bootstrapping techniques were applied. The main finding was that the presence of quality regulation did not significantly alter the behaviour of the firms, implying that cost efficiency incentives did not conflict (or trade-off) with quality-related incentives.

The empirical evidence discussed so far suggests that the incorporation of network security in efficiency benchmarking is a relatively new concept and remains unexplored both in the academic literature and in regulatory practices. A first step towards including network security in benchmarking analysis would be to establish a conceptual benchmarking framework for network security. This presents a major knowledge gap which this research will discuss in the Ghanaian context or aims to bridge to some extent in chapter 6.

3.5.3 CRITIQUE OF THE LITERATURE ON ACCOUNTING AND ELECTRICITY SECURITY OF SUPPLY

Tables 3.6a and 3.6b show the summary of the literature on accounting and electricity security of supply. Accounting rules can make a substantial difference to supervisory ratios, impeding the international comparability of key metrics required in the supervision process (Jaskow 2011). Other refinements, such as temporal fidelity, levelised avoided cost of electricity (LACE), the impact of subsidies, and the ability to incorporate performance factors (e.g., firming, shaping, storage costs) are mostly not included. LCOE addresses only cost with an assumed capacity factor.

Investments are not solely determined by costs, but on anticipated profits that are equal to revenues minus costs. Revenues are in turn determined by the selling price of electricity, which varies seasonally and diurnally. Concepts such as levelised avoided cost of electricity (LACE) are often used to compare revenues to costs with temporal specificity. Market prices for power change throughout the day, and this analysis does not take those changes into consideration. This distinction can be particularly relevant for intermittent generation technologies, as solar usually produces a greater share of its total generation during times of higher electricity prices than wind (Joskow 2011).

However, this case might also change as more renewables come online. Backup and firming costs and other system integration costs such as transmission and distribution investments are difficult to incorporate into an LCOE analysis because these require knowledge of the temporal demand and supply of electricity, which are not natively part of the LCOE equation as these costs are representative of overall electric grid, or system dynamics.

The accounting and classification issues of security costs, choice of cost drivers, data adequacy and quality and the choice of benchmarking techniques are relevant for the international comparison of energy firms. The assembling and sharing of international datasets can mitigate data availability if compatible international data are available together with a proper understanding of the practical issues involved when using international data to benchmark domestic network companies.

Table 3.3a Summary of the literature on Accounting and Electricity Security of Supply(ESoS)

Author (Year)	Study Period	Sample size	Methodology	Energy Security variable	Summary results
Growitsch et al(2010)	2001-2004	128 Norwegian Distribution Companies	Factor Analysis Methodology	Electricity Security of Supply	The choice of the type SFA model is more important than whether to include the environmental factors in them. Moreover, the difference between the levels of average efficiency scores between conventional and the Fixed Effects SFA models imply that regulators need to be aware of the extent to which the time invariant inefficiency score of the latter models for regulatory benchmarking.
Ter- Martirosyan and Kwoka (2010)	1993-1999	US firms	Regression Analysis	Electricity Security of Supply	Incentive regulation is indeed associated with significantly longer duration of service outages, although not necessarily more frequent outages. They examine the causal chain connecting incentive regulation, cost expenditure and service quality. They conclude that the careful design of quality standards can allow incentive regulation to achieve cost savings without quality degradation.
Kuosmanen (2012)	2012	89 firms in Finnland	Stochastic semi-nonparametric frontier estimation	Electricity Security of Supply	Cost differences due to heterogeneity of firms operating in heterogeneous environments should be considered in providing incentives for improving productivity and adopting the best technologies and practices.

Table 3.3b Summary of the Literature on Accounting and Electricity Security of Supply(ESoS)

Author (Year)	Study Period	Sample size	Methodology	Energy Security variable	Summary results
Jamasb et al(2012)	1995 -2003	12 UK Distribution Firms	Regression Model	Electricity Security of Supply	The regulatory incentives to reduce service interruptions have not been strong enough to achieve economically efficient levels of service quality. Again the incentives to encourage utilities to reduce network energy losses have led to performance improvement.. They estimated that the observed improvements in quality during the period of study only represented about 20 per cent of the welfare gains, hence leaving considerable scope for further economically efficient improvement in service quality.
Cambini et al(2014)	2004 - 2009	115 companies	Two-stage semi-parametric Data Envelopment Analysis (DEA)	Electricity Security of Supply	The presence of quality regulation did not significantly alter the behaviour of firms, implying costs efficiency did not conflict (trade –off) with quality related incentives.

Source: Constructed from the Empirical Literature.

3.6.0 EXIT AND ELECTRICITY SECURITY OF SUPPLY

In capacity surplus and technologically advanced economies, exit has largely been influenced by the need to promote low carbonisation, and manage price and technological shocks. Shocks can be split into several categories, notably price, quantity and technology.

3.6.1 THEORETICAL LITERATURE

In keeping with Welsh et al (2014), exit which comes from the world of economics to analyse market factors, is generally defined as the ability of one party to leave or sever the relationship with the other party (Hirschman 1970). Under energy-only market (EOM) whereby a set of assumptions has to be satisfied, including perfect correction of externalities, separation of efficiency and equity/distributive objectives, convexity of cost functions and perfect competition players can easily exit. In practice, these assumptions do not all hold. This calls for government intervention to ensure security of electricity supply. Generally, the electricity market is regulated and its development has largely been influenced by its origins which has largely depended on or have been funded by state capital leading to initial state monopolies. In addition, product demand characteristic in both capacity short or surplus economies is fairly inelastic. The social importance of electricity also strengthens the voice element in the relationship between consumers and power producers. Hirschman (1970) defines voice as any attempt at all to change, rather than to escape from, an objectionable state of affairs, whether through an individual or collective petition to the management directly in charge, through appeal to a higher authority with the intention of forcing a change in management, or through various types of actions and protests, including those that are meant to mobilise public opinion.

Following from the reforms in the highly regulated electricity markets from corporatisation to liberalisation, these regulatory actions take into account externalities and the need to ensure electricity security of supply in any democracy thereby reflecting the citizenry and government expectations. For example, in a theoretically energy-only market combined with a sufficiently high carbon price, guaranteed recovery of the high upfront fixed investment costs of renewables could plausibly ensure decarbonisation in the long term (IEA 2016).

Technological and price shocks also influence the exit of power generation plants. Price and technology are intertwined. Price shock relates to changes in the input prices for power generation and the efficiency brought about by economies of scale and scope which provides the window for investors to switch from one technology to the other. Technology shocks relate to new concepts and ideas, to failures (for example, the discovery of nuclear design faults), or to new constraints (for example, an unanticipated technical advantage of nuclear over coal with the discovery of the climate change problem).

Exit in the electricity market comes with its economic challenges in the form of stranded costs, social costs and regulatory assets. These challenges arise from uneconomic plants, competition and technological changes. Balancing these challenges influence investments and security of supply because the balancing act will influence the choice of technology and other investment related issues such a size and location (Dahl 2015).

According to IEA (2016) studies, governments have specific objectives for the deployment of specific technologies. Letting the market and a carbon price decide the level of decarbonisation and the mix would not be a problem per se, if governments had the single objective of reducing CO_2 emissions. But governments usually have a mix of objectives that determines the selection of, for example, renewables or nuclear that goes beyond CO_2 emissions.

Government policy is seeing the rejection or phasing out of nuclear power in a number of countries. Some countries would also prefer to reduce reliance on gas because it is imported or exposes consumers to long-term gas price risk. Other countries are pro-solar. It should be acknowledged that, to a certain extent, major decisions about the generation mix remain a matter of state energy policy (IEA 2016).

To date, existing sources of low-carbon generation have been built under a regulated framework. Nuclear and hydro together represent 80% of low-carbon power in OECD countries, having largely been built before the introduction of competitive electricity markets. The remaining 20% have been subsidised by renewables support schemes. Market-based, unsubsidised low-carbon investments have been negligible (IEA 2016).

3.6.2 EMPIRICAL LITERATURE

The IEA (2016) studies show that the relationship between exit and electricity security of supply is mixed from the perspective of costs and affordability depending on the country. Governments accepted the need to subsidise renewables at the initial stage of deployment, in order to benefit from lower costs subsequently as mass deployment becomes necessary. In several European countries, onshore wind and solar photovoltaics (PV) have been deployed rapidly and at high cost. These policies have been successful in reducing their associated investment costs. Onshore wind and solar PV are now mature technologies with more than 50 GW of wind and solar power added every year in OECD countries. Several governments, including Spain, Italy and the United Kingdom, have now ceased support, which has stopped new installation as their costs have not fallen sufficiently. These examples illustrate the risks associated with technology-specific support schemes.

According to Castro (2017) a significant proportion of the existing nuclear power stations will reach the end of their expected operational life time towards the end of this and beginning of the next decade. Castro (2017) cites DECC (2012) expectation that approximately 8.4 GW of nuclear supply capacity will retire by 2023.

The European Union (EU) environmental directives are leading to widespread closure of coal and oil power plants because of the requirement to implement technologies that satisfy the emission standards of the directive. The Large Combustion Plant Directive (LCPD) and the Industrial Emissions Directive (IED) have the combined effects of requiring opted-out plants to be permitted to operate for a maximum of 17,500h between 2016 and 2023 after which it must close. Again low profitability levels of gas plants have led power companies to retire gas-fired plants either permanently or temporarily (i.e. mothballing). After 2015, according to Castro (2017) the UK government has reset its priority on security of supply and affordability with emphasis now being placed on the nuclear programme, new dash for gas and has significantly reduced financial support for renewable energy sources.

In Brazil, Hunt et al. (2018) who analysed the electricity security of supply in recent times show that natural causes can lead to the reduction in the dependence on renewables notably hydro power. The introduction of price variation scheme (green, yellow and red flags) that reflects the level of power that the hydro sources can contribute to electricity security of supply reflects how price shock can positively contribute to electricity security of supply.

3.6.3 CRITIQUE OF THE LITERATURE

Table 3.8 below presents the summary of the literature on exit and electricity security of supply. The literature shows that exit policies are determined largely by government policies and the associated incentives. Given that, there is a thin line between exit and entry in capacity short economies, the emphasis placed on low-carbonisation of power generation is not the central theme as compared with ensuring the availability of electricity. The exiting of power generators therefore depend on whether the country is resource rich or poor and intends to pursue self-sufficiency and self-controllable energy resources policy (Yao et al 2018). Yao et al (2018) for example cite the Japanese Ministry of Economy, Trade and Industry (METI 2014) electricity policy- the 4th Japanese Basic Energy Plans (BEPS) in early 2014, which confirms that nuclear energy will be an important base-load source on the premise of ensuring its safety.

Empirical evidence on stranded costs and other social costs are scarce in developing and capacity short economies that intend to take out high carbon generation sources and transit to green power at heavy social and economic costs.

Table 3.4 Summary of the literature on Exit and Electricity Security of Supply(ESoS)

Author (Year)	Study Period	Sample size	Methodology	Energy Security variable	Summary results
IEA (2016)	2011-2016	OECD Countries	Documentary and Normative Analysis	Electricity Security of Supply	The relationship between exit and security of electricity supply is mixed depending on the variables under consideration such as quantity, price, cost and environmental protection.
Castro , M.(2017)	2010-2016	The UK	Sequential Monte Carlo Simulation	Electricity Security of Supply	The relationship between exit and security of supply is mixed as price changes have led to mothballing in gas fired plants but policy shift based on the security of supply is reversing such trends with focus on nuclear energy to guarantee self-controllable energy generation sources.
Hunt et al (2018)	1924-2015	Brazil	Documentary and normative analysis	Electricity Security of Supply	Positive relationship between exit caused by natural forces and the security of electricity supply subject to proper pricing of electricity to reflect generation input mix supply sources and costs.
Yao et al(2018)	2003-2018	Japan, Korea, Taiwan and Singapore	Documentary analysis and Comparative Study	Electricity Security of supply	The relationship between exit strategies in the energy sector and the security of supply depends on the importance the country in question attaches to the objective of self – sufficiency and self-controllable energy resources.

Source: Constructed from the Empirical Literature

3.7.0 SUMMARY OF PRIOR RESEARCH AND GAPS IN THE LITERATURE

Regarding the study on the relationship between regulatory structures and electricity security of supply, the literature shows that researchers (Jamasb et al 2012; Kuosmanen 2012; Cambini et al 2014; Nepal and Jamasb 2015; Cox 2016; among several others) make use of: (i) different approaches, assumptions and methods; (ii) variables and measures of entry, exit, accounting ; (iii) control and instrumental variables and their measures or proxies; (iv) block study categories(developed, developing countries; low income , middle and high income economies, OECD among others); (v) time horizon or periods for the sample data, and (vi) data types (cross-sectional or panel) among other things. The differences in the choices made might explain the mixed results and ambiguous conclusions in the existing empirical works.

Hence, the important question for research is: why is the empirical evidence mixed or ambiguous? This question triggers the following discussion that would reveal the vital differences that this research would try its best to accommodate by following or extending some of the previous studies that would make it different from them.

Firstly, many of the past studies try to analyse the effect of only one jurisdiction (Kuosmanen 2013) or certain country category (Cox 2016) or use a number factors to explain and define the power related variable. For instance, Larsen et al (2017) made their studies on electricity security using 11 elements as against IEA(2016) which used 3 elements in measuring electricity security of supply namely fuel security, system security and adequacy, while Batlle and Rodilla(2010); Vagliasindi and Besant-Jones (2013) undertook cross-country studies of electricity markets and electricity security of supply . Likewise, some of the studies focusing on accounting rules governing how a wide range of complex transactions are mapped into accounting numbers, indicate that poor mapping between fundamental activities and accounting numbers can introduce significant noise into the effect incentives provision by regulators to power distributors (Jamasb et al. 2012; Cambini et al 2014; Napal and Jamasb 2015). For example, the measurement of LOCE needed to be uniform to determine global measurement (Rhodes et al 2017). This example is extremely helpful as it draws our attention to the need to assess the direct impact of a country's characteristics on measuring the cost of electricity. This research will therefore take into account the characteristics of the Ghanaian power generation mix and market characteristics and practices in the discussion of the research findings resulting from the univariate and regression analyses.

The use of different measures of electricity security and the omission of some relevant variables might contribute to the difference in the results and ambiguity of conclusions. Hence, considering this and following IEA (2016) and Hawker et al (2017) the empirical analysis would involve a simple use of actual production as a proxy for the level of power security and in order to fill the gap of exclusion bias as mentioned in Chapter 2, section 2.7. Again, because the time period is comprehensive, it makes the current level of sample taken to be on average representative enough of Ghana's power sector electricity security of supply (ESoS) figure in this research.

Previous studies undertaking a comparative analysis of the power market legal and regulatory framework against other countries did capture the influence of the regulation in their model (Jamasb and Nepal 2015) but excluded Sub-Saharan countries. Likewise that of Vagliasindi and Besant –Jones however considered the Sub- Saharan countries but did not include Ghana and did not cover the same period as one finds in this research. Others which took Ghana into account including Kojima et al (2014) and Eberhard et al (2016) adopted a normative approach.

Finally, the empirical analysis will also use several estimation procedures to investigate the relationship between the electricity security of supply (ESoS) and the firm-level and regulatory variables. Hence, the procedures to be used are: (1) different types of robust regressions besides the OLS for primary analysis and (2) fixed effects and random effects regressions. A diagnostic analysis will be undertaken to check the consistency of the results or evidence and to handle some characteristics of the sample data including issues of heteroskedasticity, multicollinearity and autocorrelation, which violate the OLS assumptions. Such violations will necessitate the use of other estimation methods when using panel data (Apergis 2015; Hayland 2016; Atems and Hotaling 2018).

To sum up, this research would fill the gap in the literature by accounting for some of the sources of differences in results or include variables that the existing literature on electricity security of supply in Ghana had excluded. These sources are: (1) the use of simple actual power produced as a proxy to reflect the context of Ghanaian power markets (2) include relevant variables such as size of installed capacity, governance, sustainability characteristics, financial efficiency and contracting structure and ownership of power producers in the estimation procedures as drivers of electricity security of supply in the literature on Ghana in chapter 2, section 2.7; (3) apply a legal methodology in assessing the regulatory gaps and testing of other hypotheses and (4) the use of different estimation procedures for primary analysis and for sensitivity and consistency analysis.

The next chapter will therefore discuss the research philosophy and hypotheses developed for the research.

CHAPTER 4

RESEARCH PHILOSOPHY AND HYPOTHESIS DEVELOPMENT

4.1 INTRODUCTION

This chapter examines and justifies the appropriate research paradigm and the associated elements guiding this study. It seeks to achieve three additional objectives. The first is to develop the conceptual framework which shows the relationship between power market regulation and security of electricity theories and firm-level risk taking activities. The second is to critically examine the literature to understand the causal relationship that has been established theoretically and empirically between the gaps identified in the literature review in chapters 2 and 3 which included contracting structure and ownership, sustainability, financial efficiency, governance and regulatory measures and electricity security of supply. The third is to formulate the research hypotheses.

4.2 RESEARCH PHILOSOPHY

A clear research philosophy is of central importance to the efficient conduct of any research project. Among other things, it provides a basis for the methodological framework, the validity and legitimacy of the research. The researcher's philosophical view, therefore, informs and guides the whole research process. A review of the literature on research methodology and philosophies show that there are several ways in which the various paradigms have been classified. However, the various classifications can be seen as variations that lie in between two extreme points, the positivist view and the interpretivist view.

Collis and Hussey (2013) support the view that paradigm can be used at philosophical, social and technical levels. While the philosophical level reflects the basic belief about the world, the social level reflects how the research should be conducted. The technical level, however, specifies the methods and techniques that should be adopted when conducting research. The positivist paradigm posits that the social world exists externally, and that its properties should be measured through objective methods (Easterby-Smith et al 2015). The positivists' paradigm approach is usually quantitative, and characterised as being objective, scientific and traditionalists (Collis and Hussey 2013). In contrast, the interpretivist paradigm rests on the assumption that social reality is in the mind of the researcher. This paradigm is also characterised as being subjective because it is socially constructed and with each researcher having his or her own sense of reality, and there are multiple social realities (Collis and Hussey 2013).

According to Easterby–Smith et al (2015) the main strengths of the positivist paradigm are that they can provide a wide coverage of situations, fast and economical. And because most data are aggregated from large samples, they may be of considerable relevance to policy. They further argue that the positivist paradigm provides room for the researcher to focus on hard data rather than opinion, look for regularities in the data obtained; and allows for a proposition that can be generalised from a specific example to a wider population of organisations and situations. On the contrary, researchers critical to positivism argue that rich insights into this complex world are lost if such complexity is reduced entirely to a series of law-like generalisation (Saunders et al 2016). Easterby–Smith et al (2015) further discuss the limitations of positivisms as being inflexible and artificial and, in particular, not very helpful in generating theories. They further argue that much of the data gathered may not be relevant to real decisions even though it can still be used to support the covert goals of decision makers.

Interpretivism, on the other hand, has the benefit of allowing the researcher to focus on exploring the complexity of social phenomena with the view of gaining interpretative understanding (Easterby- Smith et al 2015). According to Saunders et al (2016) interpretivism is the heritage of the two intellectual traditions of phenomenology and symbolic interactionism. The use of qualitative methods is fairly complementary.

The main limitation is that beliefs determine what counts as facts. In between these two extremes are other alternative research paradigms, such as critical theory, feminism, hermeneutics, postmodernism and pragmatism theory which also represent relatively coherent ways of thinking which is promoted by influential proponents (Easterby-Smith et al 2015).

This study adopts a positivist paradigm since it seeks to investigate a phenomenon that can be said to be deterministic. Because the regulatory actions and electricity security of supply (ESoS) measures are determined by law and are exact to an individual power generating plant, a deterministic approach can be used to estimate the expected relationships. The data required for this research either already exist in various forms or can be computed from existing data. This study also proposes a number of hypotheses based on existing theories and the literature and tests these hypotheses empirically using quantitative data gathered across power generation firms and across time. Finally, the results obtained from the analysis of this data can be easily replicated.

4.3 RESEARCH APPROACH

The research approach is deductive. The main body is exploratory and therefore the focus is on getting insights and familiarity with the subject area for more rigorous analyses (Collis and Hussey 2013). The research adopts the five sequential stages through which deductive research will progress: deducing a hypothesis from theory; expressing the hypothesis in operational terms; testing the operational hypothesis; examining the specific outcome of the inquiry; and finally, if necessary, modifying the theory (Saunders et al 2016).

4.4 DEVELOPMENT OF A CONCEPTUAL FRAMEWORK

The conceptual framework (Figure 4.1) illustrates the link between regulation and the electricity security of supply. Energy or power market regulation is dynamic, and in this conceptual framework liberalisation is a dynamic process which responds to changing domestic, global economic and international regulatory changes.

Liberalisation therefore affects the existing regulatory design and structure which the underlying theories require a systematic approach to its sequencing in the form of: unbundling of generation, transmission and distribution of power

(IEA 2016). The literature on generation liberalisation and electricity security of supply shows that there appears to be an association between power market liberalisation and development of power market size and reliability in Europe and America. Therefore, the power market reforms that are sequenced with other economics of law and regulations in order to maintain economic growth, productive employment, social cohesion and innovation become extremely important (Eberhard et al 2016; Hawker et al 2017).

The structural impact of unbundling therefore follows from the entry of independent power producers; foreign joint /state –owned power plants; increased competition domestically; the inflow of foreign capital, their nature and sources; and risk management practices and technology (Eberhard et al 2016). Important regulatory measures to guarantee electricity security of supply have been varied but have led to the development of capacity markets (Rious et al 2015).

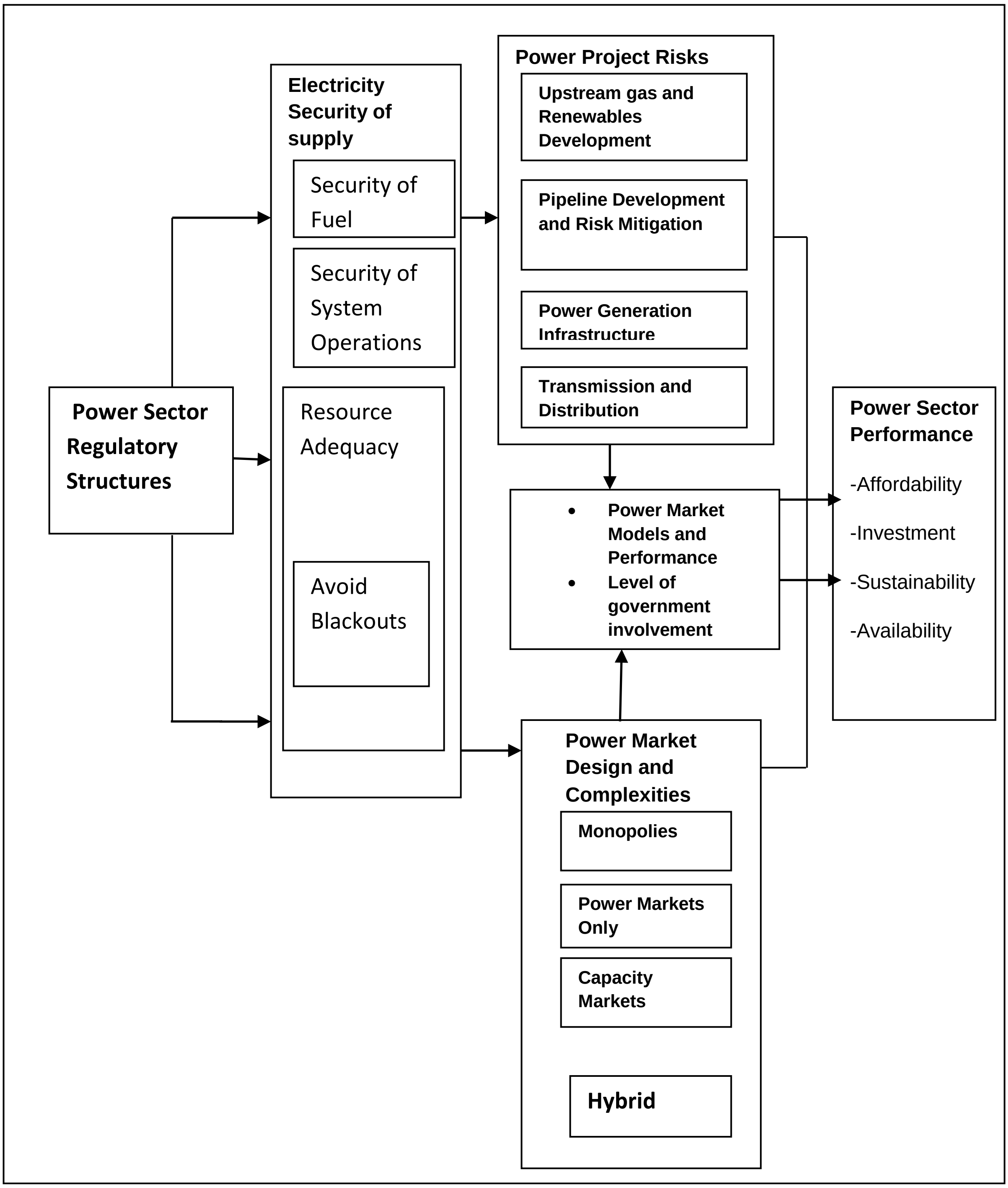
Regulatory monitoring and supervision are the day-to-day and continuous process of monitoring firms in the power value chain to avoid power failures and systemic risks of under-investments in generation and transmission systems or from any related external sources. A power producer's compliance with grid regulatory standards and achievement of good financial performance are indications of its ability to survive in the given economic and political situation (World Bank 2013).

The transaction costs theory has within its foundation the governance standards which take into account incomplete markets given the long term nature and risks associated with power projects. These governance standards give rise to market structures as spot, market only, monopoly and managed markets. The regulatory design and power market structure and supervisory standards are interrelated and they influence each other. They combine to determine the power market models, strategies and complexity of power market activities in a jurisdiction (Signorini et al 2015). Again it helps to define firm boundary decisions and how contracts are negotiated to ensure the bankability of power projects. Boundary decisions that may arise in relation to the availability of fuel, consents and agreements with respect to access to grid for the distribution of power, foreign exchange and transfer risks are considered in the Ghanaian build –own-operate –and transfer agreement the government has been signing with investors (Gulbrandsen et al 2017).

Again, these governance standards while affecting the availability of power (Best and Burke 2018) also do determine the size of power markets and access, sustainability of the system and affordability of electricity in a jurisdiction. More importantly the quality of regulatory and market design determines the speed at which the market matures to guarantee ESoS (Rious et al 2015). The conceptual framework therefore serves as the foundation of the research hypotheses.

Figure 4.1

Conceptual Framework: Electricity Security: Regulatory Structures and Power Sector Risk Management in Ghana



Source: Author's Illustration: Adapted from Vagliasindi and Besant-Jones (2013) Framework on Power Market Structures and Performance and modified by the Author.

Figure 4.1 above therefore guides the researcher to establish the relationship between the gaps in the literature discussed in chapters 2 and 3 and the hypotheses developed in this chapter.

4.5.0 HYPOTHESIS DEVELOPMENT

This section examines the various hypotheses proposed and then tested in this research. The link between the regulatory structures and electricity security of supply and other perspectives discussed in Chapter 3 (Literature Review) is used to develop the testable hypotheses for this study. This takes into account the influences of the decarbonisation of power systems or green designs (Prévost and Rivaud 2018) on the regulatory framework and its design. Five testable hypotheses are proposed based on regulatory structure, electricity security of supply (ESoS) theories and their related empirical findings.

Electricity security of supply is a broad notion comprised of three building blocks: the security of fuel (i.e. the availability of gas/coal/nuclear/hydro to generate electricity); the security of system operations (avoiding blackouts); resource adequacy (avoiding load curtailment in case of capacity shortage)(IEA 2016). These three variables are represented by the actual power generated for use in the Ghanaian economy by the respective players. The resilience of electricity systems is also increasingly important when setting technical standards of reliability regulation, as more frequent extreme heat waves or cold snaps can affect the availability of power stations, the thermal limits of networks, and the incidence of extreme load events (IEA 2016). However in

Ghana, these threats do not exist, making the availability of actual power generated and made available to the end user the key determinant. This is because the processes of availability, accessibility, and affordability capture other important characteristics such as reliability or quality of the service, supply flexibility, grid capacity adequacy and condition of grid. Again they take into account demand flexibility, regulatory efficiency, and sustainability, among others.

4.6.0 INVESTMENTS IN PLANT SIZES AND ELECTRICITY SECURITY OF SUPPLY

The size of installed capacity in a jurisdiction is important to determine the level of power generation. Investments in power systems are heavy and decisions once made have long term investment consequences. It is expected that countries with large installed capacity will have higher level of power availability.

4.6.1THEORETICAL LITERATURE

In excess capacity environment, under these “gold plating” conditions, higher investments would not necessarily lead to higher welfare, since the level of investment could be too high from a social welfare point of view. However, in recent years most European countries have switched to incentive-based forms of regulation, as for example price-cap, revenue-cap or yardstick-regulation that do not suffer from overcapitalisation where many existing assets are very close to the end of their life span and therefore tremendous amounts of replacement investments are necessary (Rious et al 2015). Guthrie (2006), states that delayed investments can be very costly from a welfare economic perspective.

One can therefore assume that higher investments in the electricity sector are desirable from a welfare perspective.

In capacity short economies, using the stylised model, Di Bella and Grigoli (2017) present two scenarios: a better equilibrium and a worse equilibrium in the electricity system of a country. They argue that depending on policy choices, there may be long-term equilibria for the electricity sector, some better than others.

A better equilibrium they suggested would be generally characterised by long – term public policy choices, geared at low theft ratio and delinquency, strong enforcement, low government subsidies, appropriate tariff setting and electricity dispatching rules. These measures they suggest would result in lower generation costs and a volume of investment that is large enough to guarantee electricity supply levels commensurate with peak demand.

Alternatively, they argue, a worse equilibrium would be characterised by high theft-ratio and government subsidies, weak enforcement, inappropriate electricity tariff setting and dispatching rules. These characteristics would generally result in a large generation cost, as well as investment in generation and distribution that result in inefficient electricity supply levels, thereby acting as a bottleneck in economic activity (Di Bella and Grigoli 2017).

4.6.2 EMPIRICAL LITERATURE

Vagliasindi and Besant-Jones (2013) who examined power markets in 23 countries covering Europe, America and African countries found that countries with larger installed capacity have better power sector performance and the relationship was significant.

Similarly, Brazil liberalised its electricity sector in the 1990s, but new markets did not attract adequate investment. Faced with one of the most serious energy crises in its history in 2001-2002, in a context of drought, Brazil resorted to developing an integrated long-term plan for the power sector (Pinguelli et al 2013). The crisis originated from insufficient hydropower generation during drier years, delays in the commissioning of new generation plants and transmission issues.

Other papers that assess the impact of restructuring, while controlling for potential endogeneity, include Gugler et al (2013), Fiorio and Florio (2013), and Pompei (2013). Gugler et al (2013) look at the impact of market reform on investment in 16 EU countries from 1998 to 2008 and find that different reform steps have opposing effects on investment in the industry. They conclude that, broadly speaking, restructuring measures that directly affect the market (such as the introduction of a wholesale-power pool) increase investment, while measures that affect the incumbent directly (such as ownership unbundling) decrease investment (Gugler et al 2013).

Spalding – Fecher et al (2017) who examined the demand and supply scenarios for the South African power pool from 2010- 2070 stressed the need for capacity installation notably gas-power generation and renewable energy sources to guarantee the security of electricity supply. They find that the potential transformation of the supply sector would require a fundamental shift in resource use, grid management and infrastructure development in the region, as well as regional integration,

Di Bella and Grigoli (2017) who comparatively studied two capacity short economies Haiti and Nicaragua from 2012 to 2015 showed that strengthening credibility leads to larger investments which boost generation create a cooperative equilibrium which leads to lowered costs, and distribution losses, and eliminate blackouts, improving efficiency and gradually lifting a constraint to economic activity. The first hypothesis is stated as:

H1: The size of a generating plant is positively related to the level of electricity security of supply in Ghana.

Table 4.1 below shows the summary of the literature on the relationship between investments in plant sizes and electricity security of supply.

Table 4.1 Summary of the Literature on Investments in plant Size and Electricity Security of Supply(ESoS)

Author (Year)	Study Period	Sample size	Methodology	Firm –level risk-taking variable	Summary results
Vagliasindi and Besant –Jones(2013)	1989- 2009	22 countries (low, middle and high income countries)	Fixed Effects Estimation and Random Effects models	Electricity Security of supply	Countries with bigger installed capacity had better power sector performance and positively impact on supply.
Gugler et al (2013)	1990 - 2008	16 EU Countries	Fixed Effects and GMM	Electricity Security of supply	Increase in installed capacity, grid and other infrastructure in excess capacity markets go with increased security of supply but with increased end user prices.
Di Bella and Grigoli (2017)	2012 -2015	2 countries system – Haiti and Nicaragua	Reduce Model	Electricity Security of Supply	They find strong evidence that a policy choice has a positive relationship with investments in installed capacity and security of supply.
Spalding – Fecher et al.(2017)	2010- 2070	South African Power Pool – 12 countries	Long Range Energy Alternatives Planning (LEAP) modelling system	Electricity Security of supply	Investments in installed capacity will positively impact on the security of supply.

Source: Constructed from the Empirical Literature.

4.7.0 FINANCIAL EFFICIENCY AND ELECTRICITY SECURITY OF SUPPLY

Vagliasindi and Besant- Jones (2013) used the average electricity tariff level as an indicator of financial efficiency in their study 22 countries. They argue that higher tariffs reflect the need to make tariffs most cost reflective. IEA (2016) provides some guidelines in identifying the role of scarcity or shortage pricing. This approach termed as energy –only markets requires that: high price caps, often above existing ones, consistent with reliability standards; ex ante market power mitigation; and some form of regulation of scarcity price formation are necessary during system stress.

First, as energy markets do not allow for sufficient demand response (at least at present), the price cannot always clear the market. In particular, most consumers are not exposed to real-time electricity prices because there is neither the physical nor market infrastructure in place. It is possible that electricity markets will not clear even in the absence of wholesale market price caps. Given that in any particular moment the supply of generation is fixed, the only alternative to a catastrophic blackout for a system operator in such a situation is controlled load-shedding. In addition to that, in the event of a system outage or blackout, generators receive no remuneration at all, and therefore markets cannot optimise the risk of large-scale blackout (IEA 2016).

4.7.1THEORETICAL LITERATURE

One important insight from the economic literature is that electricity markets cannot optimise the duration of blackouts and involuntary load curtailment. The reason is that the duration of blackouts depends on the generation capacity built to avoid them, and the incentive to build generation to avoid blackouts depends on the price being paid during blackouts. Yet there exists no competitive market price during blackouts; the price paid to generators during blackouts must be set by administrative rules.

The failure of markets to optimise blackouts goes beyond the case of rolling blackouts. For instance, when capacity becomes scarce, the probability of a network collapse increases (Joskow and Tirole 2007; Joskow 2008). However, a network collapse implies a market collapse, because, as electricity cannot be delivered during a system collapse, consumers are unwilling to pay. As a result, market mechanisms cannot capture the cost of catastrophic blackouts and thus cannot optimise their occurrence.

The literature on peak–load and scarcity pricing and investment incentives in electricity markets began with Boiteux (1949). Scarcity pricing relies on market clearing prices. The basic idea is that, where all available generation capacity is fully utilised, there may be excess demand at a spot price that is equal to the marginal production cost of the last unit provided by the physically available generating capacity. Because supply cannot meet demand in such a scarcity event, the demand side is then required to bid prices up until the market clears. At the resulting “scarcity prices”, all generators that are supplying energy earn scarcity rents, which in turn are needed to cover their fixed capital costs. This mechanism is essential to providing an incentive to invest in all energy markets (Grimm and Zöttl 2013). But it cannot help in optimising blackouts or in finding efficient prices when there is a possibility that no market-clearing price exists due to demand-side flaws. The adequacy problem is ultimately the result of demand-side market failures and not the result of regulatory price suppression (Cramton et al 2013).

Second, energy market prices are capped and cannot incentivise investment in sufficient generation to avoid load shedding in the first place. Investing in generation that may only run for a few hours a year means that the investors must earn back all of their investment costs over a relatively short period of time. Because these generators are unable to recover their fixed costs via infra-marginal rents (as most generators do), during these few hours, prices must be allowed to rise above their marginal costs. In other words, these generators must be allowed to exercise a certain degree of market power. Such high prices have been considered, for the most part, politically untenable, and so, lacking a natural mechanism for keeping such market power abuse in check. Regulators have often applied some cap on wholesale market prices. Limiting scarcity prices, however, potentially disincentivises investment in the peaking generation required for resource adequacy. It further leads to the so-called "missing money" problem, where resources are unable to recover their full investment costs through the wholesale market alone. In Texas, studies by Potomac Economics (2015) show that the public utility decided in 2014 to progressively increase the price cap in the ERCOT region from 3,000USD/MWh in 2011 to 9,000 USD/MWh from June 2015.

The existence of price caps has been the most popular explanation for the introduction of capacity markets. More recently, several studies have shed new light on this debate (Hogan 2013; Brattle Group 2013; Cramton et al 2013; FERC 2014).

4.7.2 EMPIRICAL LITERATURE

Vagliasindi and Besant –Jones (2013) in their study of 22 countries from 1989 to 2009 found that countries with higher system power-installed are characterised by significantly better performance than countries with lower installed capacity. Tariffs are lower by 25 per cent indicating a higher degree of competitiveness and that utilities are able to charge cost-oriented tariff.

Henderson (2014) who studied the Australian electricity pricing system argued that the regulator recognised that markets are never in equilibrium and that insufficient capacity could result in frequent peak prices and high profits for existing generators. Regulators in Australia and Texas have set a limit on the revenues that generators can make during such periods. In Australia regulators have introduced a cumulative price threshold: if the sum of spot prices over 336 trading intervals exceeds AUD 210, 900, the administered price cap is lowered to 300 AUD/MWh.

Accounting for the potential endogeneity of the reform process, Swadley and Yücel (2011) examine the impact of unbundling on prices and efficiency in electricity markets in 16 US states and Washington DC. The authors find that, if markets are designed correctly, retail consumers benefit from lower prices. Of the different market designs they examined, none lead to lower prices in the very short run. They also highlight that in order to see lower retail prices, consumers must actively participate in the market.

The recent study by Hayland (2016) of 27 EU countries from 2001 to 2011 using a dynamic panel –data analysis technique finds that the price of electricity paid by industrial users is positively and significantly related to the natural gas price. A 1 per cent increase in gas price is associated with a 0.48 per cent increase in the industrial end-user price. However, once the endogeneity of reforms are accounted for, restructuring has, as of yet, had no statistically significant impact on electricity prices.

The empirical studies provide mix results and in some cases show a reverse causality (Swadley and Yúcel 2011; Hayland 2016) depending on the country and time the analysis of tariffs have on electricity security of supply. This leads to the hypothesis that:

H2: The level of financial efficiency electricity prices (average tariff in $ cent per kWh) does not relate to electricity security of supply in Ghana.

From a regulatory perspective, both an energy-only market and a capacity market involve a high degree of intervention from regulators or system operators. The purely decentralised market solutions alone are unlikely to provide the accurate scarcity prices needed to meet reliability standards.

Table 4.2 Summary of the Literature on Financial Efficiency (Electricity Prices) and Electricity Security of Supply(ESoS)

Author (Year)	Study Period	Sample size	Methodology	Firm level risk-taking variable	Summary results
Swadley and Yũcel(2011)	1990-2010	16 states and the District of Columbia USA	Dynamic Panel Analysis	Seasonally adjusted real price per kilowatt / hr mark-up ratio	Retail competition makes the market more efficient by lowering the mark up of retail prices over wholesale costs. The effects of a competitive market are mixed across states but, generally appear to lower prices in states with high participation rates.
Vagliasindi and Besant – Jones(2013)	1989 -2009	22 Countries	Reduced Model	Power Sector performance	There is negative relationship between per capita capacity and tariffs.
Handerson (2014)	1999 - 2014	The entire Australian power market	Comparative study	Power sector performance	There is a positive relationship between scarcity pricing and retail pricing due to commitment to subsidise renewable energy. Scarcity pricing is only a revenue source for generators in energy-only wholesale spot market.
Hayland (2016)	2001-2011	27 EU countries	Static and Dynamic Panel Data Analysis	Prices of electricity	.Once the endogeneity of reforms are accounted for, restructuring has, as yet, had no statistically significant impact on electricity prices.

4.8.0 REGULATORY SUBSTANCE AND GOVERNANCE AND ELECTRICITY SECURITY OF SUPPLY

While matters of fundamental principle will typically be settled in a law and be authorised by the legislature, some rules need to be made that build on these principles and can be periodically adjusted without having to go through the normally long process of adopting a new law. This is the basis for the adoption of secondary rules, called regulations (Dow 2010).

4.8.1 THEORETICAL LITERATURE

Morgan and Yeung (2007) classify the theories of regulation into three main categories: public interest theories, private interest theories and institutionalist theories. Public interest theories of regulation attribute to legislators (and others responsible for the design and implementation of regulation) a desire to pursue collective goals with the aim of promoting the general welfare of the community. Private interest theories, by contrast, are skeptical of the so-called 'public interestedness' of legislators and policy-makers, recognising that regulation often benefits particular groups in society, and not always those it was ostensibly intended to benefit (Morgan and Yeung 2007). Institutionalist theories tend to emphasise the interdependency of state and non-state actors in the pursuit of both public benefit and private gain within regulatory regimes (Morgan and Yeung 2007). Although these theories originally focused on implementing regulation, they have powerful implications for uncovering the processes of how regulatory regimes emerge and their implications which challenge divisions between public and private institutions or actors (Morgan and Yeung 2007).

Joskow (2008) shows that from costs and quality perspectives and in line with public interest, one of the primary goals of regulation is to stimulate the regulated firm to produce output efficiently. Glachant et al (2013) show that to achieve this goal, regulation should be designed to incentivise producers and suggest that the theory of incentive regulation is founded on the idea that there is an information asymmetry between the regulator (principal) and the agent (the firm in the power market). The regulator knows well neither the cost function called the adverse selection problem nor the level of effort that the firm could make to reduce costs and produce more (moral hazard problem). Glachant et al (2013) therefore argue that the key properties of regulatory regime to incentivise investments are fourfold: the capability to provide sufficient remuneration to investors in the power sector to ensure their financeability; the capability to reduce their cost of capital; the capability to incentivise the power market players to reduce their costs; and the capability to transfer efficiency gains and redistribution to final users.

Regulations complement laws and contracts, filling in the details are essential to their implementation. Typically, legislation should authorise the competent authority to make regulations from time to time, providing the detail and procedures by which to implement the policy objectives for the extractive industry sector and by reference to specific enabling provisions of the legislation (Cameron and Stanley 2017).

Regulations are subsidiary instruments of the extractive industry sector legislation and should never be inconsistent with it. Regulations should focus primarily on technical and operational matters (such as licensing procedures; contract area; monitoring, inspection, and control of operations; reports on operations; and operational standards) but may also include fiscal elements (such as royalty definitions, surface rental, fees, and fines), cost and volume audits, and/ or social and environmental requirements. In some cases, regulations may even specify the competent authority or authorities in the extractive industry sector. In the area of local benefit, one can expect the general principles to be set out in a basic law, but the detail is better suited to regulations, involving specific mechanisms to achieve the law's general objectives (Duval et al 2009; Cameron and Stanley 2017).

4.8.2 EMPIRICAL LITERATURE

The other two studies on econometric modelling of electricity market reforms come from two papers by Nagayama (2007, 2009). Nagayama (2007) used panel data for 83 countries covering the period1985–2002 to examine how each policy instrument of the reform measures influenced electricity prices for countries in Latin America, the former Soviet Union, and Eastern Europe. The study found that variables such as the entry of independent power producers (IPP), the unbundling of generation and transmission, the establishment of a regulatory agency, and the introduction of a wholesale spot market have had a variety of impacts on electricity prices, some of which were not always consistent with expected results. The research findings suggest that neither unbundling nor the introduction of a wholesale pool market on their own necessarily reduces the electricity prices. In fact, contrary to expectations, there was a tendency for the prices to rise. He argues, however, coexistent with an independent regulator, unbundling may work to reduce electricity prices. He found that privatisation, the introduction of foreign IPP and retail competition lower electricity prices in some regions, but not in all regions (Nagayama 2009).

In his second paper, Nagayama (2009) aimed at clarifying whether the effects of power sector reforms should be different either across regions, or between developing and developed countries. He analysed an empirical model to observe the impact of power prices on the selection of a liberalisation model in the power sector. This was achieved by the use of ordered response, fixed effect and random effect models. An instrument variable technique was also used to estimate the impact of the liberalisation model on the power price. These econometric models were designed using panel data from 78 countries in four regions (developed countries, Asian developing countries, the former Soviet Union and Eastern Europe, and Latin America) for the period from1985 to 2003.The research findings suggested that higher electricity prices are one of the driving forces for governments to adopt liberalisation models. However, the development of liberalisation models in the power sector does not necessarily reduce electricity prices. In fact, contrary to expectations, the study found that there was a tendency for the prices to rise in every market model (Nagayama 2009.

The presence of an autonomous regulator is also significantly and positively associated with higher tariffs, reflecting the need to insulate crucial decisions related to pricing from political interferences. The presence of an autonomous regulator is also significantly associated with lower carbon emissions. This proves that overall environmental considerations have achieved a higher priority compared to the traditional functions of energy policy and regulation, such as to protect consumers from high prices and ensure that power companies will be able to recoup their investment.

Further empirical evidence on the effects of restructuring electricity markets is provided by Erdogdu (2011). Using a panel of 63 developed and developing countries, using fixed effects and random effects models, Erdogdu (2011) finds no consistent effects of restructuring on electricity price-cost margins and concludes that reforms have heterogeneous impacts across countries.

Vagliasindi and Besant-Jones (2013) who examined power markets in 22 countries covering Europe, America and African countries found that the introduction of an autonomous regulator is significantly and positively associated with higher access, confirming that regulators can also help ensure that contracts are effectively designed. The presence of an autonomous regulator has also significantly contributed to higher labour productivity, most likely by creating a more even playing field to attract private participation in distribution.

Florio (2014), examined the impact of regulatory oversight in the context of restructuring energy markets in the EU, noted the continued importance of economic regulation to protect consumers. As the electricity sector becomes increasingly subject to both privatisation and market forces, there is a clear need for regulation to ensure that the benefits from restructuring are passed on to consumers and to protect more vulnerable consumer groups. This additional need for effective regulatory oversight may itself lead to higher costs, potentially offsetting other cost savings.

Thamae et al (2015) empirically quantified and measured the performance of the electricity sector regulator in Lesotho for the period 2004-2014. The assessment was carried out by determining a regulatory governance index (RGI) and an index of regulatory substance (IRS), and using regulatory impact measures and metrics to assess overall performance of regulation. They found that regulatory reforms failed to attract new players in the electricity supply industry (ESI) over the review period, especially private-sector participation in generation activities. These may have resulted from technical constraints associated with the relatively small scale of Lesotho's electricity grid (peak less than 150 MW), weak economic and political institutions, and less skilled human resources. They further argue that lags of some years between the establishment of the regulator and any significant increases in investment should be expected because the time needed to establish regulatory credibility is unclear.

Eberhard et al (2016) who examined 13 Sub-Saharan countries and the effect of their regulatory measures found that regulators' existence did not significantly affect the efficiency of the power sector. This was due to the degree of their independence and how they were finance. We therefore state the third hypothesis as follows:

H3: The quality of regulatory substance and governance is positively related to the level of electricity security of supply in Ghana.

Table 4.3 shows the summary of literature on the relationship between regulation (substance and governance) and electricity security of supply.

Table 4.3 Summary of the Literature on Regulation(Substance and Governance) and Electricity Security of Electricity Supply (ESoS)

Author (Year)	Study Period	Sample size	Methodology	Firm risk-taking variable	Summary results
INagayama (2007)	1985-2002	83 countries	Panel Regression	Electricity Security of supply	The co-existence of a regulator with unbundling may work to reduce prices or improve security of supply.
Nagayama (2009)	1985 -2003	78 countries	Econometric Model	Electricity Security of supply	The development of liberalised models in the power market does not necessarily reduce electricity prices or the expected level of efficiency.
Erdogdu (2011)	1982 - 2009	63 developed and developing countries	Fixed and Random Effects Models	Electricity Security of supply	The impact of regulatory reforms on the security of supply is heterogeneous.
Vagliasindi and Besant –Jones(2013	1989-2009	22 countries	Fixed and Random Effects	Power Market Performance	The impact of regulatory presence on the security of supply is heterogeneous. It depended on the income and size o the power market.
Thamae et al (2015)	2004 -2014	Country study Lesotho	Principal Component Approach	Electricity Security of Supply	The impact of regulatory presence on the security of electricity supply is mixed.
Eberhard et al(2016)	1994-2014	5 Countries	Comparative	Electricity Security of Supply	The presence of an independent regulator had impacted positively on IPP investments and the security of supply.

Source: Constructed from the Empirical Literature.

4.9.0 SUSTAINABILITY AND ELECTRICITY SECURITY OF SUPPLY

Sustainability is defined to have many dimensions including environmental sustainability, domestic supply of fuel or power and fossil fuel dependency, affordability, profitability or viability of power firms (Larsen et al 2017).

Discussion persists on whether environmental sustainability should be considered as one of the dimensions of ESoS. Although Chalvatzis et al (2009) and Gracceva and Zeniewski (2014) implicitly split environmental sustainability and energy security into the environmental consequences of energy production and consumption and how they affect energy systems. It is equally argued using the Brazilian case as an example, that climate change has an effect on water patterns and availability (Kileber and Parente 2015). According to van Vliet et al (2016) over two thirds of hydropower plants will face a reduction in their capacity due to reduced inflows and increased sedimentation.

Thermoelectric plants will also be affected as they use large amounts of water for their cooling systems. Given that 98 percent of world generation comes from these two sources, this impact cannot be ignored (van Vliet et al 2016). Climate change is also expected to affect the demand-side; for instance, Eskeland and Mideksa (2010) show that in Europe an increase in temperature will result in significantly higher demand for electricity.

Given the complexity of measuring the extent to which electricity-related environmental factors affect the electricity sector, Larsen et al (2017) focus on the driver of climate change, emissions, a directly measurable environmental aspect. They propose the annual carbon emissions per unit of production, e.g., TWh. Depending on a country's characteristics, other emissions, such as sulphur, particles or NOx, may need to be considered.

Another strand of literature looks at the fossil fuel dependency as opposed to renewable sources. This is based on economic and environmental aspects: fossil-fuels are expected to become more expensive not only because of the environmental commitments, but also because of their depletion (Costantini et al 2007).

Another strand of literature also analyses sustainability from a geopolitical perspective. They argue that import dependency is seen as a threat because of some suppliers' political instability (Chester 2010; Vivoda 2010). There are numerous examples of countries using gas as a political instrument; examples include Russia (Bloomberg 2015) and Bolivia (Barrionuevo 2007**)**. Dependency on imported gas for electricity is recognised as a threat to ESoS.

While the increased interconnection of electricity markets has been seen as a major achievement of foreign policy to promote ESoS, this exposes the system to threats of cascade failures (Nepal and Jamasb 2013). Furthermore, reliance on imported electricity might decrease investment incentives in the long-term (Ochoa and van Ackere 2009). The degree to which a country is vulnerable depends on the concentration of imports. The argument is extended by including vulnerability in the sustainability drivers' mix. This dimension focuses on the concentration of imports, which depends on volumes imported and the number of jurisdictions where imports come from. As was the case for the resilience of generation capacity, the aim is to highlight the risk of relying on a limited number of fuels, or on electricity from a few jurisdictions. The ESoS in the importing jurisdiction could be seriously endangered in case of political problems or extreme weather conditions in the exporting jurisdictions.

4.9.1THEORETICAL LITERATURE

Using a stylised model of income, resource endowments, and electricity mix, Burke (2010) assumes a simple, open economy, where there are three electricity sources: domestic, imported, and modern. Domestic sources include hydroelectricity and indigenous fuel reserves, while imported fuel resources include fossil fuels (oil, coal, and natural gas). Modern sources are capital, human capital and institution-intensive energy sources, such as nuclear power and modern renewable (including wind and solar). He suggests that at an early stage of development, domestic energy resources might initially be preferred (lowest net cost) will be hydroelectricity production, and the most accessible fuels first. Second, where available, domestic resources can be utilised with lower transaction costs (primarily transport costs) than imported energy resources. Third, the use of domestic resources minimises requirements for foreign exchange, access to which is costly and constrained in poor countries. Fourth is that the use of domestic energy resources has more favourable domestic employment, income, government revenue implications than the use of imported energy sources. Fifth, the use of domestic resources reduces exposure to energy security risks associated with reliance on imported energy sources.

Hydro capacity, where available, is likely to be favoured for electricity generation even over domestic fossil fuels, because it is renewable, not exportable (apart from as electricity), and of little utility in satisfying energy demand in other sectors of the economy (such as transportation).

He argues that for several reasons the unit costs of modern electricity sources might fall with greater income. Modern electricity is capital, labour, and capital intensive, meaning that they require large amounts of capital investment, a highly skilled workforce, an enabling governance environment characterised by mature energy-sector institutions. He hypothesises that as countries develop they typically experience reductions in the costs of financing, improved access to foreign exchange, and growth in human institutional capital. As a result, modern electricity sources become increasingly viable as incomes increase. Further, wealthier countries are better able to exploit the economies of scale available in electricity generation (due to bigger market size), which favour capital intensive modern electricity sources.

Although the model does not consider the features of electricity –sector investment, such as learning effects and uncertainties over costs, the distinction between different fuel types the model establishes the relationship between sustainability choices among countries based on the endowment effects. The model therefore features diminishing returns to electricity generation from domestic energy resources and increasing affordability of modern energy sources as countries develop, and implies a general electricity ladder that sees countries transition from domestic resources, to imported fuels, and finally to capital intensive modern electricity sources, as per capita income rises. The model also implies that the extent to which any country climbs the electricity ladder as it develops is a negative function of domestic endowment.

Omri et al.(2015) discuss the four testable hypothesis to explain the causal relationship between energy consumption(demand or security of supply) and economic growth. The four hypotheses are feedback, growth, conservation and neutrality. They stress from the neutrality hypothesis that the reason which conducts researchers to focus on the link between energy resources and economic growth is the vision of sustainable development.

4.9.2 EMPIRICAL LITERATURE

Burke (2010) examined a sample of 133 countries by using regression estimation methods. Using cross-sectional and panel data from 1960 to 2004, they found that there is strong evidence of an endowment effect on the electricity mix. Countries with large geothermal resources (as proxied by the number of volcanoes per capita), for instance, are significantly likely to generate geothermal electricity than otherwise similar countries. Countries with a large endowment of fresh water are more likely to base their electricity sectors on hydro power and countries are likely to base their electricity sector on fossil fuel that are domestically available. Energy endowments are one potential source of cross-country heterogeneity in the long run relationship between income and carbon dioxide.

The estimated income effect is negative for the hydro and oil share of the electricity mix and positive for coal, natural gas, nuclear, biomass and waste, and wind (significant at 5 per cent level or higher). The estimated income effect on the geothermal share of electricity mix is statistically insignificant.

Erdogdu (2014) examined the relationship between investment, security of supply and sustainability in 55 developed countries from 1975-2010. Using fixed and random effects estimation models, he finds that the increase in the size of the industry sector seems to increase emissions from electricity generation in developed countries but a decrease in them in developing ones. In developed countries, income level, population density and share of rural population have a negative correlation with lower levels of emission. In developing countries, the study shows that there is not a specific link between these variables and emission from electricity generation.

Narayan and Doytch (2017) examined the consumption of electricity for renewable and non-renewable sources based on the level of a country's income level in 89 countries from 1971 to 2011. Four groups, high income (HI), Upper Middle Income (UMI), Low and Lower Middle Income (LLMI). They find that non-renewable energy consumption grew fastest in low and lower middle income countries, the energy deficient countries. This is followed by upper middle income and high income countries. The mean renewable energy consumption total as a percentage of total final consumption is highest for low income countries. This is followed by middle income countries. This is same for renewable industrial (or residential) energy consumption. They observe a recent increased use of renewable energy use in low and lower middle income countries mainly due to residential energy consumption (Narayan and Doytch 2017).

Given the sustainability and its implications on electricity generation mix, and Ghana being a low middle income country it is expected that its position on the electricity ladder will be influenced by its endowment factors given the current utilisation of gas from domestic gas fields and legacy hydro resources, and the abundance of solar resources. The fourth hypothesis is therefore presented as:

H4: The level of sustainability practices of the power generating firms is positively related to electricity security of supply in Ghana.

Table 4.4 Summary of the literature on Sustainability and Electricity Security of Supply (ESoS)

Author (Year)	**Study Period**	**Sample size**	**Methodology**	**Firm risk-taking variable**	**Summary results**
Burke(2010)	1960 -2004	133 Countries	Pooled OLS and Fixed Effects	Electricity Security of Supply	The results are consistent with an electricity ladder that sees countries substitute , in relative terms, from hydroelectricity and oil toward, coal, natural gas, nuclear and modern renewable as they develop.
Erdorgdu(2014)	1975 - 2010	55 developed and developing countries	Fixed –Effects and Random Effects models	Electricity Security of Supply	The increase in the size of the industry sector seems to increase emissions from electricity generation in developed countries but decreased in developing countries.
Narayan and Doytch (2017)	1971-2011	89 Countries	System GMM	Electricity Security of Supply or Energy Consumption	The efficient use of energy and adoption of renewable energy is mainly driving the negative growth for non-renewable use in high income countries and upper middle countries. Non-renewable energy consumption grew fastest in the low and lower middle income countries that are energy deficient. This is followed by upper middle income and high income countries.

Source: Constructed from the Empirical Literature.

4.10.0 OWNERSHIP/ PRIVATE PARTICIPATION AND ELECTRICITY SECURITY OF SUPPLY

The petroleum regime serves as the legal framework with varying qualifications to deal with all issues relating to contractual, property, administrative and competition law that arise from petroleum negotiations(Stickley 2006:71). Inherent in all negotiations is the extent to which the risk of managing the expectations of investors and the host country is best addressed (Gao1994). Besides, these expectations are conflicts that arise from differences in the timing of expected benefits, risk considerations and allocation of project outcomes. These situations further lead to political risks in addition to geophysical and commercial risks, among others.

Ownership constitutes a business risk as most of oil and gas fields are owned by the state or state-owned corporations which implies that most energy investment decisions will not only be based on commercial viability(Duval et al. 2009; Eberhard et al 2017), but primarily on the national energy priorities of a given country(Yao et al 2018) . Edomah et al (2017) suggest that investments in the gas-to –power value chain tend to focus on places that understand that a balanced partnership increases the value of the enterprise for all parties. Stevens and Hulbert (2012) further suggest that one of the key drivers of current and future investment for most oil and gas players lies in the policy direction of the target countries irrespective of the short term political changes that every country faces.

The introduction of private sector participation in generation also is significantly linked to access expansions, proving that IPPs and divestiture of formerly state-owned generators can deliver positive results. The introduction of private sector participation also helps to significantly enhance operational efficiency and labour productivity in distribution.

4.10.1 THEORETICAL LITERATURE

The academic literature on the theory of privatisation is copious and forms a subset of a large literature on the economics of ownership and the role for government ownership of productive resources (Muhlenkamp 2013). The ownership structure of firms in the electricity sector may affect investments in two ways, first via efficiency and second via incentive or objective effects. Unambiguously, more efficient firms invest more, because they serve a larger market including also low-willingness-to pay consumers (a demand effect) and/or because they obtain a larger market share (a competitive effect). Therefore, if public ownership implies x-inefficiency, we should see less investment in predominantly state-controlled energy sectors. On the other hand, the state and state controlled firms may have objectives or incentives that differ from privately controlled firms and these objectives may include the build-up of a good and secure infrastructure for electricity (Gugler et al 2013).

Public activity tends to improve when divested as divestiture reduces political influence and increases the influence of capital market factors. The fiscal considerations to undertake privatisation are also important as they provide government with incentives to undertake the privatisation in raising cash and eliminating public subsidies to state-owned firms. Moreover, the fiscal benefits of privatisation are related to the efficiency and welfare advantages of private ownership, as the government is better off keeping the firms in public ownership and receiving the stream of profits if the public ownership is optimal (Guriev and Megginson 2007).

In contrast, Nepal and Foster (2015) make some mixed findings in their study of the Australian power system. Studies opposing electricity privatisation have criticised the same ‘free market’ models of electricity supply in Victoria attributing to a record of failures in improving electricity affordability and reliability over 20 years of reforms (Quiggin 2014). The transmission and distribution networks remain state-owned in Tasmania (TAS), NSW, QLD and part of the Australian Capital Territory (ACT). A rapidly growing number of households are suffering from energy impoverishment caused by escalating electricity prices in Victoria contradicting the proclaimed benefits of lower electricity prices from the restructuring and privatisation of the electricity sector (Chester 2014).

4.10.2 EMPIRICAL LITERATURE

Empirical studies relating the ownership structures and electricity security of supply in excess capacity economies show mixed results. Pompei (2013) looks at the effect of regulatory reform in the OECD on total factor productivity (TFP) growth in the electricity sector. He found that reforms to promote competitiveness lead to some general benefits, but with some negative impacts on efficiency. Breaking TFP growth into frontier shift (technological change) , catching up (pure efficiency gains), and movement toward the optimal scale of production (scale efficiency improvements), he found that less strict entry regulation is associated with increased technological change and that vertical integration has a negative impact on pure efficiency. He also found that higher levels of public ownership (that is lower levels of privatisation) are positively related to improvements in scale efficiency. The author stresses the importance of looking at the subcomponents of liberalisation when assessing its effects (Pompei 2013).

Gugler et al (2013) come to a rather negative conclusion concerning the dynamic effects of ownership unbundling of the transmission grid. Unbundling of ownership of the generation from the grid stages reduces the aggregate investment rate in the sector by about 10 percent.They estimated an investment reducing effect of forced third party access to the transmission grid. Higher electricity end-user prices induce higher investments in the overall sector.
Not arguing that competition introduced via regulation per se reduces investments, the findings suggest instead that the way competition is introduced has important consequences. Giving entrants direct access to the incumbent's network via cost based access charges or ownership unbundling the incumbent's grid from other stages of the supply chain, introduces vertical diseconomies and non-internalisation of network effects and spill overs, such that the net effect on aggregate investment is negative, at least in electricity markets. Introducing competition via market based measures – such as establishing a wholesale market for electricity or abolishing minimum consumption thresholds for switching to alternative suppliers – increases aggregate investment spending. These measures increase competition and investment spending without destroying the incentives of the incumbent to invest (Gugler et al 2013).

Fiorio and Florio (2013) also look at restructuring for a subset of European countries (the EU-15). Using a longer time series, they look at the evolution of electricity prices for the period 1978 to 2006 and investigate how they have been affected by energy-market liberalisation generally and ownership structure specifically. They find that the impact of liberalisation on prices is mixed but that private ownership is significantly associated with higher prices. Therefore the impact of ownership and the mode of ownership changes have mixed effects depending on the country.

Ajayi et al (2017) examined the cost efficiency and electricity market structure in 25 EU countries from 1980 to 2009 using an econometric model. The panel data analysed using pseudo –maximum likelihood methods showed that public ownership and vertical integration are found to be associated with high efficiency loss while no statistically significant relationship established for entry barriers. Public and state ownership they found hinders the reduction in generation costs that can be achieved during periods of market reform. Privatisation appears to be a more efficient policy to pursue (Ajayi et al 2017). The final hypothesis is therefore stated as:

H5: The ownership of the power generation plants is not related to the level of electricity security of supply in Ghana.

Table 4.5 below presents the summary of the literature on ownership structures and electricity security of supply.

Table 4.5 Summary of the literature on Ownership and Electricity Security of Supply(ESoS)

Author (Year)	Study Period	Sample size	Methodology	Firm risk-taking variable	Summary results
Fiorio and Florio(2013)	1978 -2008	EU 15 countries	Static Panel Model plus GMM	Electricity Security of Supply	Consumer prices are lower in countries where public ownership has been preserved and public ownership in electricity industry is not associated with less market opening.
Gugler et al (2013)	1998-2008	16 EU Countries	OLS and GMM Model	Electricity Security of Supply	Restructuring measures that directly affect the market (such as the introduction of a wholesale-power pool) increase investment, while measures that affect the incumbent directly (such as ownership unbundling) decrease investment..
Pompei (2013)	1994-2007	19 EU Countries	Dynamic GMM Model	Electricity Security of Supply	Public ownership positively influence scale efficiency changes. High levels of public in the ownership structure of electrical companies guarantee improvements in reaching the optimal scale of production.
Ajayi et al (2017)	1980 -2009	25 countries	Pseudo – Maximum Likelihood Methods	Electricity Security of Supply	Public and state ownership hinders the reduction in generation costs. Public ownership and vertical integration are found to be associated with high efficiency loss while no statistically significant relationship established for entry barriers.

Source: Constructed from the Empirical Literature.

4.11.0 CHAPTER SUMMARY

The chapter discussed the research philosophy and the development of the hypotheses for the study. The research paradigm provides the direction to be taken in the research methodology. Table 4.6 presents the summary of the hypotheses developed. In the next chapter, the methodology to test the hypotheses developed for the study will be presented.

Table 4.6: Summary of Hypotheses

Variables	**Hypothesis**	**Expected sign of the relationship**
H1: Size	The size of a generating plant or capacity is positively related to the level of electricity security of supply in Ghana.	Positive (+)
H2: Financial Efficiency	The level of electricity prices is not related to electricity security of supply in Ghana.	Positive (+) or negative (-).
H3: Regulation(governance and Substance)	The quality of regulatory substance and governance is positively related to the level of electricity security of supply in Ghana.	Positive (+)
H4: Sustainability	The level of sustainability practices of generation plants is positively related to electricity security of supply in Ghana.	Positive (+)
H5: Ownership	The ownership of the power generation plants is not related to the level of electricity security of supply in Ghana.	Positive (+) or Negative(-)

Source: Constructed from the Hypotheses Formulated by the Author

CHAPTER 5

METHODOLOGY

5.1 INTRODUCTION

This chapter describes the research methodology of this study. It describes the problem space and ways that other researchers have studied the problems of electricity security of supply, regulatory and power generation value chain risk taking activities. The design of the methodology is based on prior research into the relationships as discussed in Chapter 4. The method is intended to provide a robust repeatable method by which the research questions can be answered. This chapter, therefore, describes the method of data collection, the variables used to test the hypotheses and the statistical and legal techniques employed.

5.2.0 SAMPLE AND PERIOD SELECTION

The period of study is 10 years from 2007 to 2016 and covers the period that the power sector in Ghana faced capacity challenges and required that the mix of power generation had to be changed which also needed financial and technological injections into the sector. The focus of the study is on the activities of power producers, so the sample does not include power firms yet to contribute to power supply in Ghana. There are currently 17 power generating firms in Ghana accounting for almost 99 percent of the power consumed in the country over the period. Three of these firms, namely Takoradi 3, BCX Company and VRA Solar, were dropped from the study because they did not have the necessary 10 years generation data required for the computation of the level of electricity security of supply. Again where the plant has been rented such as the Karpower plant it was considered as VRA's owned output. Some IPPs were combined such as Cenit Energy Company and Asogli Power. In addition foreign sources including CIPRAL of La Cote d'Ivore were included for regular power import.

The final sample consists of 9 sources of power supply, accounting for 70 percent of the existing power generation population. In terms of power generation, the combined 9 groups account for 99 percent of the actual power generated in Ghana. Appendix 5.1 provides the summary of the sampling procedure and sample size. According to Pallant (2007), different authors tend to give different guidelines concerning the number of observations required for multiple regression tests. Stevens (1996) cited in Pallant (2007) recommends that for social science research, about 15 data points per predictor are needed for regression models. Tabachnick and Fidell (2007) suggest a rule of thumb for determining the minimum sample size, N, for a regression analysis as, 50 plus 8 times the number of independent variables in the regression model (M). Thus:

$N = 50 + 8M$.

The minimum sample size ensures that the number of observations in the statistical analysis is large enough to achieve sufficient statistical power and reduce estimation error. Going by Tabachnick and Fidell (2007), this implies our model, with five independent variables, will need 90 cases. The sample of 9 sources over the ten-year period results in a balanced panel of 90 power-year observations.

5.3 DATA COLLECTION METHODS

The following section discusses the method of data collection and type of data that were collected to conduct the study. The data for the study are compiled from different sources. Firm -specific data, including their annual reports, are obtained from the Investor Relations Departments of the various power producers. The reports are further verified for consistency from World Bank sources, the Statistical Service and Energy Commission of Ghana.

5.3.1 ASSUMPTIONS

All the sampled firms are not on the stock exchange. Therefore, to determine their values and ascertain their compliance with the relevant International Reporting Standards (IFRs), the research first takes into account the stakeholders who have investment interest and influence on the governance of the firms' operations who also seek to obtain reliable data for their decision making. Considering the relevance of data integrity and reliability to this research, data from different stakeholder sources including the Ministries of Energy and Finance provided to the public are compared with that from the World Bank, IMF, IFC, and the IEA. The World Bank in particular has a vested interest in the Ghanaian power market development through the funding support from its development financing agencies in addition to the co-guarantees for some of the loans by a preference lender like the IFC towards the development of the Ghanaian energy sector. Data from these sources serve as a reliable check of data quality provided and verified from government sources. Again, in the absence of the market values, the balance sheet figures will be as close as we can get.

5.3.2 DATA COLLECTED

The following data and information have been collected. The 10 years annual reports of all the 9 power generation sources published by the World Bank, Energy Commission and Electricity Company of Ghana. The VRA being the single –buyer model facilitator in Ghana also provides some data. For each power provider and for each year over the period 2007 to 2016, the following performance data and regulatory data items were collected:

(i) Total power generated ;

(ii) Price received or market value of power produced per kilowatt;

(iii) Dependency on imported fuel or type of fuel;

(iv) Regulatory relationship;

(v) Structure of ownership; and

(vi) Indirect and direct Government of Ghana shareholdings. Shareholdings of quasi-state institutions, notably the Volta River Authority and Social Security and National Insurance Trust (SSNIT), in each power producer.

(vii) The legal agreements including IPP and legislation supporting the legal framework of the Ghanaian power systems.

As all the data outlined above are publicly available, either from the power firms themselves or other official sources, it is believed that the use and analysis of the data do not raise any ethical concerns, such as the confidentiality and anonymity of subjects, potential harm to participants, conflict of interest on the part of the researcher, and other general issues of access to data.

5.4.0 DATA PREPARATION AND MEASUREMENT OF VARIABLES

The first preparatory analysis technique is preparation of logarithms (logs) for some of the data. Mathematical logs are used in econometrics analysis for several reasons. First, because of their size reduction properties, they reduce the scale of raw data, which will make it easier to compare small institutions to larger institutions. This is particularly important because the sizes of the plants in this study vary widely; if you consider that some of the plants included have higher installed capacity than others, then the scale problem becomes clear. In effect, logs perform the same function that the ratios calculated for some of the variables discussed below do, by making it possible to compare firms of different sizes.

The natural log function (ln) can be applied to dependent or independent variables (Gujarati and Porter 2009). The independent variables installed capacity or size and financial efficiency are prepared to have logs.

The second is the use of dummy variables. In regression analysis, the dependent variable is also influenced not only by ratio scale variables but also variables that are essentially qualitative or nominal scale in nature such as the origin of a power generator which can be foreign or local. Such variables usually indicate the presence or absence of a ‘quality’ or an attribute (Gujarati and Porter 2009). One way to quantify such attribute is by constructing artificial variables that take on values of 1 or 0, 1 indicating the presence of that attribute and 0 indicating the absence of that attribute. In this research ownership type is treated as a dummy variable (Gujarati and Porter 2009).

The third is the use of ordinal scales. It is used to measure a higher level of utility (Gujarati and Porter 2009). Therefore in this research, a scale of 1- 6 is used to measure the level of regulation (substance and governance) and their impact. Using a scale of 1- 6; 6 will represent the highest and 1 the least.

The fourth is the use of ratio scales. Statistically, a ratio scale is the highest level of data because it has a defined zero so that data can be compared by interval and ratio (Oakshott 2006; Easterby –Smith et al 2015). The dependent variable is measured using a ratio scale.

5.5.0 MEASURES OF ELECTRCITY SECURITY OF SUPPLY (ESoS)

This section discusses the measures of electricity security of supply in the Ghanaian context. In keeping with Gugler et al (2013), Erdogdu (2014), IEA (2016), the measure of ESoS include the availability of electricity actually generated by plants in a jurisdiction. Following Grave et al (2012) supply adequacy in electricity markets is defined by ensuring sufficient capacity investment in the medium to long-term. Roques (2008) separates it further into three dimensions as follows: ensuring an optimal level of overall generation capacity at the equilibrium consistent with socially optimal system reliability design criteria; ensuring an optimal timing of investment minimising fluctuations of installed generation capacity due to power plant investment cycles and the impact of transitory adjustment periods on the security of supply; and ensuring an optimal mix of different generation technologies, both in terms of load profile (mix of base load and peaking units) and in terms of fuel mix. The security of supply in electricity generation can be measured by so-called generation capacity balances (ENTSO-E 2015). A capacity balance allows for a general overview of electricity peak demand and the contribution of each energy source to cover that demand. Capacity balances are time invariant instruments and are therefore static in their nature; a balance can be compiled for one single or several points in time during each year. To secure adequate supply in electricity generation, the total available generation capacity has to be at least as high as electricity demand for the investigated period of time.

Since electricity is a combination of inputs and transformation in generation plants, outputs provide a proxy for the level of security in a capacity short economy. Castro (2017) critically examines the measure of ESoS by using the loss of load expectation (LOLE), which is a probabilistic metric that quantifies the expected number of hours per year in which the available supply falls short of the demand. Though the metric is a widely used security of supply criterion due to its flexibility and simplicity of application, Castro(2017) argues that it only offers a simple indication of the expected likelihood of encountering deficits as it does not provide any information about the magnitude (power and energy), frequency and duration of supply shortfall conditions.

Following Nicolosi and Fürsch (2009) in this research, the electricity security of supply is measured as the actual amount of power generated discounted by the installed capacity (i.e. actual production/ installed capacity) to measure the standard effective contribution by each plant to a unitless measured figure. This approach has been applied in several studies to estimate the contribution of renewals to capacity adequacy (Petitet et al 2017).

5.6.0 MEASUREMENT OF CONTROL VARIABLES: FIRM-LEVEL VARIABLES

This section explains how the relevant generator-specific and other control variables that drive electricity security of supply are measured. The generator characteristics include generator size or endowment, the price of electricity or the main source of cost recovery and sustainability practices.

5.6.1 Power System Size

Following the existing literature, including Erdogdu (2014) the research first focuses primarily on installed capacity on absolute basis. Second, and following Hyland (2016), power system size is measured as the natural log of the installed capacity.

5.6.2 Financial Efficiency

Following Vagliasindi and Besant –Jones (2013), this is measured as the average tariff $ cent per kWh. This is the revenue received by generators to cover their cost of producing power on average. This indicates the main source of revenue for cost recovery in full or cash (Kojima et al 2014).

5.6.3 Sustainability Practices

This follows the adoption of a framework by Burke (2010) by using the endowment effect analysis, which also reflects in the Larsen et al (2017) framework for sustainability in electricity sector. This research takes into account five environmental risk variables namely: domestic source of inputs; affordability of input fuel (foreign exchange); influence of the weather;

geopolitical and imported power. The following weights were applied. Domestic availability of inputs attracts 50 points, no foreign exchange challenges takes 30 points, the influence of weather takes 10 points and the security and reliability of input or power flow which could be influenced by political or social insecurity takes 10 points and CO_2 emissions 20 points. The lack of these risks attracts a full score and the existence of any reduces the score to zero.

5.7.0 MEASUREMENT OF CONTROL VARIABLES: REGULATORY DESIGN VARIABLES

As discussed in Chapter 4, this study also examines the impact of the regulatory environment (both internal and external), on electricity security of supply. The variables considered here are regulatory governance maturity, regulatory independence of the power firm due to the level of private participation in ownership. The construction of the variables is described below.

5.7.1 Regulatory (Substance and Governance) Impact

Following Thamae et al (2015) we construct a regulatory index of 1to 6 to represent the main regulatory measures and scored if the measure is observed to have been put in place or enforced. Regulation (substance and governance) includes regulatory presence. It is defined by the establishment of the regulatory authority backed by the law or legislative instrument and actions such as the separation of transmission from generation and distribution. Aside from regulatory presence, five additional elements are included. They include: regulatory review; tariff adjustment pass-through mechanisms; quality of service regulations; regulatory accounting; and network connection policy or guidelines.

Regulatory review of price–caps to include renewable electricity generation and the increased licensing of firms within the various segments are the other components of regulatory substance. In the area of tariff setting, the observation was the existence of rate –setting guidelines and methodology.

In addition, the existence of tariff adjustment or pass-through mechanisms and whether it is used. Considering the quality of service regulation, it is assessed whether guidelines of quality of service regulation have been developed and whether quality of service is related to tariff setting. Another issue is regulatory accounting guidelines. It is also ascertained if regulatory accounting guidelines have been developed and whether there is a uniform system of reporting. The National Grid Code is expected to be in place to support the unbundling of the power sector. However, how it relates to renewable and potential IPPs are also considered.

The existence of network connection policy or guidelines are also considered in line with the need for an open access pricing guidelines or framework under any effectively regulated power sector (Thamae et al 2015).

5.7.2 Ownership

Following Gugler et al (2013), Pompei (2013), Foiro and Florio (2013) we construct a dummy variable that takes the value of 0 if the power producer is a private sector participant (or no significant state or quasi –state influence) and 1 if government or other quasi-state institutions, such as VRA and or SSNIT, have a significant shareholding in the ownership of the plant.

5.8.0 STATISTICAL ANALYSIS OF THE DATA

This section discusses the statistical methods used in analysing the data collected and to test the various hypotheses developed in Chapter 4. The analysis of the data is in two stages. The first stage, the univariate analysis, involves the use of descriptive statistics, correlation analysis and the test of means to explore trends in the ESoS measures and their relationships with regulatory and power generating firms' characteristics. The next is the multivariate analysis which involves the use of panel data methodology to test the various relationships.

5.8.1 UNIVARIATE ANALYSIS

The descriptive statistics provide a broad overview of the data, and the distributional properties of the various variables. These include the mean, median, standard deviation, range of scores, skewness and kurtosis. The Shapiro- Wilk test for normality is also used to test if the various variables are normally distributed.

The correlation analysis involves pair-wise correlations of the various variables using both the parametric Pearson correlation and the non-parametric Spearman rank correlation. Since the commonly-used Pearson correlation measure can be affected by nonlinearities in the data, the Spearman rank correlation is used to check the robustness of the Pearson correlation measure. If there are no significant nonlinearities in the data, the results from these two measures would be consistent with each other.

An independent t-test is used to determine whether there is a significant difference between two sets of means for two different groups of subjects. In this study, the independent sample t-test is used to test if there are significant differences in the security of energy characteristics across different power producers or groups (e.g. hydro versus thermal plants and IPPs and state-owned producing plants).

5.8.2 MODEL SPECIFICATION FOR THE MULTIVARIATE ANALYSIS

As noted earlier, this study examines repeated measures of electricity security of supply and their determinants for a cross-section of power plants over the period 2007 to 2016. This thesis employs a panel data analytical framework to investigate the relationship between the electricity security of supply and regulatory and power market risk variables. The panel data analytical framework adopted in this thesis is consistent with electricity security of supply and regulatory structure studies by Vagliasndi and Besant –Jones (2013), Erdogdu (2014) amongst others. In this case, the method of analysis is that of multiple regressions and the method of estimation may be pooled ordinary least squares (OLS), random effects or fixed effects models as described later in this section. As the data has cross-section and time dimensions, panel data regression analysis is commonly used in the literature to analyse data sets consisting of repeated measures on cross-sectional units such as individuals, firms, or countries, at different points in time.

Initially, the panel data regression model in its general form was estimated as follows:

$$Y_{it} = \beta_0 + \beta_1 X_{it} + \;\ldots\ldots\ldots.. + \beta_k X_{kit} + U_{it} \;\ldots\ldots\ldots\ldots\ldots.\text{(Equation 1)}$$

Where:

- Y_{it} is the dependent variable
- X_{it} represents the explanatory variables
- $i = 1 \ldots\ldots\ldots, N$ firms
- $t = 1 \ldots\ldots\ldots, T$ time periods
- β_0 represents the constant term
- β_1 is the coefficient of the explanatory variables
- U_{it} represents the error term

The error term can further be decomposed into two components in the form of a firm-specific error v_i and an idiosyncratic errorε_{it}. Thus:

$U_{it} = v_i + \varepsilon_{it}$ …………………………………...................... (Equation 2)

The idiosyncratic error term in panel data changes over time and across firms. However, depending on the behaviour of the error term U_{it} and whether the explanatory variable is serially correlated with the components of the error term v_i and ε_{it} would determine the empirical model specification.

Fundamentally, there are three standard panel data regression models that arise from the general model described in equation (1) above with specific assumptions in relation to the explanatory variables, the properties of the error term, and the association between the explanatory variables and the error term. In addition, further assumptions need to be made regarding the variability of the regression coefficient across firms. In this respect, and as has been indicated earlier, a panel data regression model in this thesis may be estimated by pooled OLS, random effects or fixed effects models and are discussed below.

5.8.2.1 Pooled Ordinary Least Squares (Pooled OLS)

Pooled OLS assumes constant coefficients, that is, referring to both intercepts and slopes. In the event that there is neither a significant firm-specific effect nor significant temporal effects, it could be possible to pool all of the data and run a pooled OLS regression model. Thus, the typical assumptions of constant variance (homoskedasticity), exogeneity, observations on the independent variables are not stochastic but fixed repeated samples without measurement errors; and uncorrelated observations (multicollinearity) must continue to hold (Green 2008).

In this thesis the Pooled OLS regression is estimated in the following general form:

$Y_{it} = \beta_0 + \beta_1 X_{it} + U_{it}$ … … … … … … … … … … … … … … … … ….Equation 3

Basically, the estimated Pooled OLS regression will be biased because of unobserved heterogeneity (X_{it} and u_{it} are correlated). But the bias may be lower because the Pooled OLS regression relies on between firm comparisons as well as within variation compared to the cross-sectional OLS regression.

5.8.2.2 Random Effects Model (RE)

A random effects model assumes that the unobserved differences are not correlated with any of the explanatory variables. That is, v_i are treated as random constant terms (Green 2012) where the intercept is a random outcome variable. The specific benefit of using the random effects model is that, the regressors allowed time-invariant variables to be included. In this instance, the random error v_i is heterogeneity specific to a cross sectional unit and in this case, power firms. This random error is assumed to be constant over time (Schmidheiny, 2014). The equation of the random effects regression becomes:

$Y_{it} = \beta_0 + \beta_1 X_{it} + v_i + \varepsilon_{it}$ …………………………………………Equation 4

Where v_i is between–firm error and ε_{it} is within–firm error. Thus, v_i are assumed to be random variables and that $Cov(X_{it,} v_i) = 0$.

But if $Cov\ (X_{it,} v_i) \neq 0$ the random effects estimator will be biased (Schmidheiny 2014). In this thesis, the Hausman specification test is used to test on whether the random-effects estimator is biased or not.

5.8.2.3 The Fixed Effects Model (FE)

The fixed effects model assumes constant slopes but different intercepts for cross sectional (group) units, and in this case individual power producers, thus, the intercept is the cross section (group) specific that differs from generator to generator. Further, the error term (ε_{it}) is assumed to be correlated with the explanatory variables. Even though there are no significant temporal effects when using the fixed effects model, there are significant differences among firms. Thus, the fixed effects model is employed whenever one is only interested in analysing the impact of variables that may vary over time. In this respect, it may be used to explore the relationship between the explanatory variables (power firm characteristics and regulatory variables) and electricity security of supply within a generator. This means that each generator has its own individual characteristics that may or may not affect the explanatory or the dependent variables.

If these individual characteristics within a generator may impact or bias the explanatory variables or the dependent variables, then one needs to control for these individual firm characteristics.

In this thesis, the fixed effects model is in the following general form:

$Y_{it} = \beta_1 X_{it} + v_i + \varepsilon_{it}$ … … … … … … … … … … … … … … … … … … …Equation 5

Where v_i is the unobservable firm-specific effect which differs between generators and is time-invariant.

McManus (2011) shows that the fixed effects model is not a panacea for all endogeneity bias such as time –varying unobserved effects, time –varying measurement error, simultaneity or feedback loops. Again time – constant effects are removed in addition to the possibility of providing poor estimates where there is little variation. FE is criticised as trading consistency for efficiency as it uses only within-unit change and ignores between–unit variation. There is therefore the possibility of parameter estimates being imprecise leading to large standard errors.

5.9.0 THE BENEFITS OF USING PANEL DATA ANALYSIS TECHNIQUES

Hsiao (2007) discusses the typical benefits and challenges of using the panel data framework. The benefits include a greater number of data points, which increases the degrees of freedom, provides more variability in the sample data set, and leads to more reliable parameter estimates and accurate statistical inferences. The use of a panel data framework also offers the opportunity to control for unobserved individual specific effects in the data set. The empirical models used and their estimation processes are discussed below.

5.10 THE CHOICE OF EMPIRICAL MODEL SPECIFICATION

For the purpose of empirical model specification for data analysis, the assumptions of panel regression need to be tested in order to determine the best fit empirical model specification for the unique data set used in this thesis. The Breusch and Pagan (1980) Langrange Multiplier is used in this thesis to choose between pooled OLS regression and the alternatives of random effects and fixed effects models.

Pathan (2009) suggests that the test could be used to determine whether or not there is heterogeneity. If the pooled OLS estimator is found to be inconsistent and biased due to unobserved variables, then, the choice between random effects model or fixed effects model is decided by the Hausman specification test to help distinguish between the consistency and efficiency of the estimators. Fundamentally, if this thesis employs pooled OLS regression and the unobserved variables are uncorrelated with the error term $(u_{it})$and the independent variables when the random effects regression is suitable, the OLS estimator will be consistent but not efficient. However, if there are no unobserved variables which are unlikely to hold in this thesis, then OLS will be efficient. Otherwise, the random effects regression will be more consistent and efficient.

In the same vein, if a pooled OLS regression is employed when a fixed effects regression is suitable, the OLS estimator will be inconsistent while the fixed effects model will be consistent. Also, if a random effects regression is used when fixed effects regression is suitable, then the random effects model will be inconsistent. In this respect, one needs to be very careful in choosing a suitable estimator in this thesis.

Following that, the Hausman specification test will be used to distinguish between random effects and fixed effects regressions for the empirical analysis in Chapter 7. The Hausman test assumes that the individual and/or time effects are not correlated with the independent variables, in which case the random effects model would be suitable. This assumption is tested against the alternative of the presence of fixed effects in the data set. If there are fixed effects, then estimates from the random-effects model will be biased and inconsistent and, therefore, unsuitable. Hence, if the null of the Hausman test is rejected, then the fixed effects estimation would be used. It is however argued, that failure to reject the null hypothesis in the Hausman test does not necessarily mean the random effects assumption is true.

An alternative to the Hausman test is the Breusch-Pagan test proposed by Breusch and Pagan (1980). However, Moulton and Randolph (1989) show that the asymptotic properties of this test statistic can be poor, even in large samples. Given the relatively small sample size in this study and the fact that none of these specification tests are fully efficient, the asymptotic properties of these tests may not hold for this sample. Hence, the results from the specification tests should be interpreted with caution.

5.11 THE EMPIRICAL MODEL

The empirical model follows Erdogdu (2011) , Battaglia and Gallo(2015) and Polemis(2016). The empirical specification of the basic model used in this study is as follows:

$$Z_{it} = a_0 + a_1 S_{it} + a_2 G_{it} + a_3 R_{it} + a_4 F_{it} + a_5 OR_i + w_{it} \quad \text{Equation 6}$$

Where:

- Z_{it} is the Electricity Security of Supply(ESoS) and is the ratio of actual production to installed capacity and the dependent variable (DV) where i = entity or generator and t = time period
- G_{it} is a generator size, expressed in natural log form
- $O_{i,t}$ is the indicator variable for ownership structure
- S_{it} is the index rating variable for sustainability
- $R_{it}$is the index rating variable for regulation(substance and governance)
- F_i is financial efficiency or tariff level
- $a_i,\ i = 1, 2, \ldots, 5$ are the respective slope coefficients
- $w_{it}$is the error term and
- a_0 is the intercept.

5.12 ROBUSTNESS TEST OF RESULTS

Based on this, we estimate instrumented regressions, applying consistent estimation techniques such as GMM and relying on both, external as well as internal instruments. The generalised method of moments (GMM) estimation for linear and non-linear models was formalised by Hansen (1982). Following Hayashi (2000), the linear regression model in equation 7 is expressed as

$$y_t = z_t'\delta_0 + \varepsilon_t, t = 1, \dots \dots .., n \qquad Equation\ 7$$

where z_t is an L × 1 vector of explanatory variables, δ_0 is a vector of unknown coefficients and $\varepsilon_t$is a random error term. y_t is the dependent variable.

Equation 7 allows for the possibility that some or all of the elements of $z_t$may be correlated with the error term ε_t i.e., $E[z_{tk}\ \varepsilon_t\ ] \neq 0$ for some k, the number of instrumental variables. If $E[z_{tk}\ \varepsilon_t\ ] \neq\ 0$ then z_{tk} is an endogenous variable. It is well known that if z_t contains endogenous variables, then the least squares estimator of δ_0 in equation 7 is biased and inconsistent.

In Equation 7, it is assumed that there exists a K ×1 vector of instrumental variables x_t which may contain some or all of the elements of z_t. We let w_t represent the vector of unique and non-constant elements of $\{y_t, z_t, x_t\ \}$. It is assumed that $\{w_t\ \}$ is a stationary and ergodic stochastic process.

The instrumental variables $x_t$satisfy the set of K orthogonality conditions:

$$E[g_t(w_t, \delta_0)] = E[x_t\varepsilon_t] = E[x_t(y_t - z_t'\delta_0)] = 0 \qquad Equation\ 8$$

where $g_t(w_t\ , \delta_t) = x_t\ \ \varepsilon_t m = x_t(y_t - z_t'\delta_0)$. Expanding (Equation 8), gives the relation

$$\Sigma_{xy} = \Sigma_{xz}\delta_0$$

where Σ_{xy}= $E[x_t y_t\ ]\ \ and\ \ \Sigma_{xz}$ =$E[x_t z_t'\ ]$. For identification of δ_0, it is required that the K ×L matrix $E[x_t\ \ z_t']$ = Σ_{xz} be of full rank L. This rank condition ensures that δ_0 is the unique solution to (Equation 8). Note, if K = L, then Σ_{xz}Σxz is invertible and $\delta_0$may be determined using $\Sigma_{xz}^{-1}\Sigma_{xy}$ (Hayashi 2000).

A necessary condition for the identification of δ_0 is the order condition

$$K \geq L \qquad Equation\ 9,$$

which simply states that the number of instrumental variables must be greater than or equal to the number of explanatory variables in (Equation 7). If K = L then δ_0 is said to be (apparently) just identified; if K > L then δ_0 is said to be (apparently) over-identified; if K < L then δ_0 is not identified.

In other words, the rank condition rank $(\Sigma_{xz}) = L$ $\qquad Equation\ 10$,

must also be satisfied for identification.

In the regression model (Equation 7), the error terms are allowed to be conditionally heteroskedastic as well as serially correlated. For the case in which ε_t is conditionally heteroskedastic, it is assumed that $\{g_t\}$ = $\{x_t\varepsilon_t\}$ is a stationary and ergodic martingale difference sequence (MDS) satisfying E$[g_t g_t']$ = E$[x_t x_t' \varepsilon_t^2]$ = S where S is a non-singular K × K matrix. The matrix S is the asymptotic variance-covariance matrix of the sample moments $\bar{g}$= $n^{-1}\Sigma_{t=1}^{n}$ $g_t(w_t\delta_0)$ (Hayashi 2000).

This follows from the central limit theorem for ergodic stationary martingale difference sequences (Hayashi 2000):

$$\sqrt{ng} = \frac{1}{\sqrt{n}} \sum_{t=1}^{n} x_t\varepsilon_t \xrightarrow{d} N(0, S)$$

where avar($\bar{g}$) = S denotes the variance-covariance matrix of the limiting distribution of $\sqrt{ng}$. For the case in which ε_t is serially correlated and possibly conditionally heteroskedastic as well, it is assumed that $\{g_t\}$ = $\{x_t\varepsilon_t\}$ is a stationary and ergodic stochastic process that satisfies

$$\sqrt{ng} = \frac{1}{\sqrt{n}} \sum_{t=1}^{n} x_t\varepsilon_t \xrightarrow{d} N(0, S)$$

$$S = \sum_{J=-\infty}^{n} \Gamma_J = \Gamma_0 + \sum_{J=1}^{\infty} (\Gamma_J + \Gamma_J')$$

Where $\Gamma_j = E[g_t\, g_{t-j}'] = E[x_t\, x_{t-j}' \varepsilon_t \varepsilon_{t-j}]$. In the above, avar($\bar{g}$) = S is also referred to as the long-run variance of $\bar{g}$ (Hayashi 2000).

To compute any of the efficient GMM estimators, a consistent estimate of $\boldsymbol{S} = avar(\bar{g})$is required. The method used to estimate $\boldsymbol{S}$ depends on the time series properties of the population moment conditions g_t. If the population moment conditions $g_t(\theta_0)$ are an ergodic-stationary but serially correlated process then:

$S = avar(g) = \Gamma_0 + \sum_{j=1}^{\infty} (\Gamma_j + \Gamma'_j)$ where $\Gamma_j = E[g_t(\theta_0) g_{t-j}(\theta_0)']$.

In the case of heteroskedasticity and autocorrelation consistent (HAC) estimate of ***S***, which has the form:

$$\hat{S}_{HAC} = \frac{1}{n} \sum_{j=1}^{n-1} w_{j,n} \left(\hat{\Gamma}_j(\hat{\theta}) + \hat{\Gamma}'_j(\hat{\theta})\right)$$

where $w_{j,n}$ $(j = 1, \ldots \ldots \ldots.., b_n)$ are kernel function weights, b_n is a non-negative bandwidth parameter that may depend on the sample size,

$\hat{\Gamma}_j(\hat{\theta}) = \frac{1}{n} \sum_{t=j+1}^{n} g_t(\hat{\theta}) g_{t-j}(\hat{\theta})'$, and $\hat{\theta}$ is a consistent estimate of θ_0. A standard of correcting the presence of potential heteroskedasticity and autocorrelation in the panel data is by using heteroskedasticity and autocorrelation consistent (HAC) standard errors proposed by Newey and West (1987) . Therefore, to make the results robust to heteroskedasticity and autocorrelation the robust and HAC Bartlett-Newey West kernel options are specified when using the STATA Generalised Method of Moments (GMM).

The independent variables are instrumented and by using the wmatrix and variance-covariance (vce) options appropriate that allows either for errors that are independent and identically distributed; or are independent but not identically distributed that exhibit heteroskedasticity and autocorrelation. The wmatrix specifies the type of weight matrix to be used in conjunction with the two-step and iterated GMM estimators. The validity of the instruments is tested using the Hansen's J test statistic of overidentifying restrictions. In all cases, the test statistic accepts the null hypothesis that the instruments are exogenous (Roodman 2006).

5.13 INTERPRETATION OF RESULTS: TESTING FOR SIGNIFICANT RELATIONSHIPS AND DIFFERENCES

5.13.1 The Development and Use Null and Alternative Hypothesis

In the language of statistics, the stated hypothesis is known as the null hypothesis and is denoted by the symbol H_0. The null hypothesis is usually tested against an alternative hypothesis (also known as maintained hypothesis) denoted by H_1. According to Gujarati and Porter (2009:113) the theory of hypothesis testing is concerned with developing rules or procedures for deciding whether to reject or not reject the null hypothesis. They show that there are two mutually complementary approaches to devising such rules, namely confidence interval or test of significance. A test of significance is a procedure by which sample results are used to verify the truth or falsity of a null hypothesis. The key idea behind tests of significance is that of a test statistic (estimator) and the sample distribution of such a statistic under the null hypothesis. The decision to accept or reject H_0 is made on the basis of the value of the test statistic obtained from the data at hand. (Gujarati and Porter 2009: 115).

Gujarati and Porter (2009) show that under confidence interval the researcher constructs a 100(1- α) % confidence interval for the true value of a parameter. (1- α) is known as the confidence coefficient and α (0 < α >1) is the level of significance. The problem of statistical testing is to establish if a given observation or finding is compatible with some stated hypothesis or not. If the true value of the parameter falls within the confidence interval, we do not reject H_0 but if it falls outside this interval, we reject H_0.

Both of these approaches predict that the variable (statistic or estimator) under consideration has some probability distribution and that hypothesis testing involves making statements or assertions about the value(s) of the parameter(s) of such distribution such as the normal, F-test (F), T-test(T), or Chi-square(χ^2) (Gujarati and Porter 2009).

5.13.2 Types of Hypotheses Developed

Creswell (2014) shows that in quantitative research, the researcher can use the traditional null hypothesis, or directional hypothesis or nondirectional hypothesis. The traditional null hypothesis in quantitative research represents the traditional approach to writing hypothesis. It makes a prediction that, in the general population, no relationship or significant difference exists between groups on a variable (Creswell 2014: 231).

A directional hypothesis is one in which the researcher makes a prediction about the expected direction or outcomes of the study (Creswell 2014: 145). A nondirectional hypothesis is one in which the researcher makes a prediction but the exact form of differences (e.g. higher, lower or more) is not specified because the researcher does not know what can be predicted from past literature(Creswell 2014: 146).

The hypotheses should be formulated from the empirical literature (Gujarati and Porter 2009). Creswell (2014) provides further guidance that in formulating the hypothesis the phrases and the positioning of variables should follow a pattern of word order. Again the use of variables should follow three basic approaches. The researcher may compare groups of an independent variable to see its impact on a dependent variable. Alternatively, a researcher may relate one or more independent variable to one or more dependent variable. The third may describe responses to the independent, mediating, or dependent variables. In keeping with Creswell (2014) the quantitative aspect of this research falls into the first and second approaches.

In formulating the hypothesis, the independent variable is stated first, concluding with the dependent in left –to- right order. In keeping with Creswell (2014) five (5) quantitative research hypotheses were developed. Two of the hypotheses were quantitative null hypotheses (Creswell 2014) which made predictions that in the general population, no significant relationship existed between financial efficiency (H_2), ownership(H_5)and electricity security of supply (ESoS). Three directional hypotheses (Creswell 2014:144-146) were discussed which made predictions about the expected direction or outcome of the study between the size of generating plant (H_1), the level of regulation (H_3), the sustainability practices (H_4) and electricity security of supply (ESoS) in Ghana.

5.13.3 Type I and Type II errors

Inevitably errors can occur when making inferences from samples. Statisticians refer to these as Type I and Type II errors. Using an analogy of legal decisions to explain Type I and Type II errors, Blumberg et al (2014) cited in Saunders et al (2016) equate a Type I error to a person who is innocent being unjustly convicted and a Type II error to a person who is guilty of a crime being unjustly acquitted. In this research, a Type I might involve drawing a conclusion that two variables are related when they are not or incorrectly concluding that a sample statistic exceeds the value that would be expected by chance alone. This will mean that the null hypothesis is being rejected when it should not. The term statistical significance therefore refers to the probability of making a Type I error. Likewise Type II error might involve drawing a conclusion that two variables are not related when they are or that the sample statistic does not exceed the value that would be expected by chance alone.

5.13.4 The Definition and Use of the *p*-Values for Interpretation of Test Results

More technically, the p-value is defined as the lowest significance level at which a null hypothesis can be rejected (Gujarati and Porter 2009:122). The p-value is the smallest level of significance at which the null hypothesis can be rejected.

The p-value provides a precise information on the strength of the evidence. If the p-value is less than the specified level of significance, we reject the null hypothesis. Otherwise we do not reject the null hypothesis. In statistics, when we reject the null hypothesis, we say that our finding is statistically significant.

On the other hand, when we do not reject the null hypothesis, we say that our finding is not statistically significant (Gujarati and Porter 2009:114). Thus, applied econometricians generally follow the practice of setting the value of α(alpha) at a 1 or a 5 or at most a 10 percent level and choose a statistic that would make the probability of committing Type II error as small as possible(Gujarati and Porter 2009:122).

Figure 5.1: Chance of making a Type I and Type II Errors

		Chance of making a:	
		Type I	**Type II**
Significance Level	**0.10**	**Increased**	**Decreased**
	0.01	**Decreased**	**Increased**

Source: Saunders et al (2016: 539) Type I and Type II Errors and modified by the Author using empirical literature.

Given that a Type II error is the inverse of a Type I error, it follows that if the chances of making a Type I error is by setting the significance level to 0.01 rather than 0.10, the chance of making a Type II error is by a corresponding amount. This is not an insurmountable problem as researchers usually consider that, Type I errors are more serious and prefer to take a small chance of saying something is true when it is not as shown in Figure 5.1(Fig 5.1). It is therefore generally more important to minimise Type I than Type II errors.

Since 1 minus the probability of committing a Type II error is known as the power of the test, this procedure amounts to maximising the power of the test. The dilemma of choosing the appropriate value of α (alpha) can be avoided by using what is known as the p value (i.e., the probability value) of the test statistic. This is also known as the observed or exact level of significance or the exact probability of committing a Type I error (Gujarati and Porter 2009:122).

In keeping with DeFusco et al (2007), the research adopts the p-value (the probability value) approach to hypothesis testing. The p value is also known as the observed or exact level of significance or the exact probability of committing a Type I error. More technically the p value is defined as the lowest significance level at which a null hypothesis can be rejected. This is the marginal significance level associated with hypothesis testing. The smaller the p-value is, the stronger the evidence against the null hypothesis and in favour of the alternative hypothesis. The p-value for a two –sided tests that a parameter equals zero is generated automatically by the STATA or the econometric software programme. The p-values serve as the alternative to using rejection points. If the p-value is less than our specified level of significance, we reject the null hypothesis and accept the alternative hypothesis. The p-value however provides more precise information on the strength of the evidence than does the rejection points approach. For example, the p-value of 0.006 indicates that the null is rejected at a far smaller level of significance than 0.01, 0.05 and 0.10(De Fusco et al 2007).

In keeping with Creswell (2014) and Gujarati and Porter (2009), in interpreting the test results using the p-values, where the p-values are small enough to reject the null hypothesis (H_0) , we will have the opposite interpretation (Park 2011). Considering the three directional or alternative hypotheses (H_1, H_3, H_4) formulated in this research any test that leads to the conclusion as to 'do not reject' the alternative hypotheses, would mean that the null hypotheses 'cannot' be accepted.

In keeping with Gujarati and Porter (2009) in 'accepting' the traditional null hypothesis we should always be aware that another null hypothesis may be equally compatible with the data. It is therefore preferable to conclude the statistical tests as 'do not reject' rather than say 'accept' (Gujarati and Porter 2009: 119).

The p-values also tell us whether a variable has statistically significant predictive capacity in the presence of other variables, that is, whether it adds something to the equation. However, caution should be exercised here because a variable that does not have a predictive power in the presence of other predictors may have predictive capability when some of these predictors are removed from the model.

5.13.5 Implications for the 5 Hypotheses

In keeping with Gujarati and Porter (2009) and the work of applied econometric researchers in energy studies including, Burke (2010); Hayland (2016); Burke and Porter (2018); the level of significance in this research is set at the 1%, 5% and 10% levels. The p -values will be used to test if we 'do or do not reject' the null or directional hypothesis in question. In keeping with Gujarati and Porter (2009:114), where the null is rejected at the 1% level and the probability of committing a Type I (i.e.α) is a small number, it will be described as highly statistically significant. The use of moderately significant and significant will be used where the probability of committing a Type I error is at 5% and 10%, respectively.

5.14 OAXACA – BLINDER DECOMPOSITION TECHNIQUE

The STATA software is used to undertake the decomposition of the differences in the ESoS scores between the hydro and the thermal plants. This procedure known in the literature as the Blinder – Oaxaca decomposition (Blinder 1973; Oaxaca 1973) divides the electricity security of supply differentials between the hydro and thermal plants into a part that is 'explained' by group differences in firm characteristics and compliance with regulations and a residual part that cannot be accounted for by such differences in electricity security of supply. The unexplained part is often used as a measure of discrimination for policy preference, but it also subsumes the effect of group differences in unobserved predictors. In other words, the Blinder- Oaxaca will be used to assess how much of the gap in electricity security of supply between the hydro and thermal plants is due to characteristics (the explained variable) and how much is due to policy or system changes (the unexplained variable). The reason is to find out how much of the mean outcome difference, is accounted for by group differences in the predictors.

Empirically, Antoni et al (2015) used it to examine the wage differentials between renewable and non-renewable establishments in Germany in 2009, using a sample of 3215 renewable energy establishments. Likewise, Morikawa (2012) also used it to assess the population density and efficiency in energy consumption from 2007 to 2008 in Japan. The application of Blinder-Oaxaca decomposition method in the power sector in Sub-Saharan Africa is scare.

Jann (2008) shows the methods and formulae as follows: given two groups hydro power (A) and thermal power (B), an outcome variable Y and a set of predictors, the difference in the mean outcome is defined as

$$R = E(Y_A) - E(Y_B) \; ; \qquad Equation\ 11\ .$$

Where:

- R is the difference in the mean outcome.
- (Y_A) is the expected value of hydro power outcome variable.
- $E(Y_B)$ is the expected value of thermal power outcome variable.

The expected value of each outcome variable is accounted for by group differences in the predictors.

Based on the linear model:

$$Y_l = X_l'\beta_l + \epsilon_l \,, \quad E(\epsilon_l) = 0, \;\; l \in \{A, B\} \qquad Equation\ 12.$$

Where:

- Y_l is the dependent variable or electricity security of supply contribution of hydro(A) and thermal(B) power producers in Ghana.
- X is a vector containing the predictors(power market size, financial efficiency, sustainability, regulation (substance and governance), ownership).
- β is a constant which contains the slope parameters and the intercept .
- ϵ is the error term.

- l =1 ...., N power firms.

The mean outcome difference can be expressed as the difference in the linear prediction at the group-specific means of the regressors (Jann 2008:2).

That is: $R = EY_A - EY_B = E(X_A)'\ \beta_A - E(X_B)'\ \beta_B$ $\quad Equation\ 13$

Since, $E(Y_l) = E(X_l'\beta_l + \epsilon_l) = E(X_l'\beta_l) + E(\epsilon_l) = E(X_l)'\ \beta_l$ $\quad Equation\ 14$

with $E(\beta_l) = \beta_l\ and\ E(\epsilon_l) = 0\ by\ assumption.$

Jann (2008) contends that the identification of the contribution of group differences in the predictors to the overall outcome difference in equation 13 can be rearranged as shown in Equation 15 below.

$$R = [E(X_A) - E(X_B)]'\beta_B + E(X_B)'(\beta_A - \beta_B) + [E(X_A) - E(X_B)]'(\beta_A - \beta_B) \quad Equation\ 15$$

The rearrangement results in a 'three–fold' decomposition or the outcome difference is divided into three parts: $R = E + C + I$ (Jann 2008:2).

The first summand $E = [E(X_A) - E(X_B)]'\beta_B$ amounts to the part of the differential that is due to group differences in the predictors (the "endowment effect"). The second component $C = E(X_B)'(\beta_A - \beta_B)$ measures the contribution of differences in the coefficients (including differences in the intercept). The third summand $I = [E(X_A) - E(X_B)]'(\beta_A - \beta_B)$ is the interaction term accounting for the fact that differences in endowment and coefficients exist simultaneously between the two groups (Jann 2008:3).

Jann (2008) further explains that the Equation 15 is formulated from the viewpoint of thermal plants (Group B). This means that the group differences in the predictors are weighted by the coefficients of thermal firms to determine the endowment effect (E) which measures the expected change in thermal plants' mean outcome, if thermal plants had hydro plants' predictor levels. Similarly, the second component (C), the differences in coefficients are weighted by thermal plants' predictor levels, which measure the expected change in thermal plants' mean outcome if thermal plants had hydro plants' coefficients.

Alternatively, Equation 16 is formulated from the viewpoint of hydro plants (Group A). The endowment effect amounts to the expected change of hydro plants' mean outcome, if hydro plants had thermal plants' predictor levels. The coefficient effect quantifies the expected change in hydro plants' mean outcome if they had thermal plants' coefficient. Following Jann (2008: 3), this reverse three-fold decomposition can also be expressed as:

$$R = [E(X_A) - E(X_B)]'\beta_A + E(X_A)'(\beta_A - \beta_B) - [E(X_A) - E(X_B)]'(\beta_A - \beta_B) \quad Equation\ 16$$

The first summand $E = [E(X_A) - E(X_B)]'\beta_A$ amounts to the part of the differential that is due to group differences in the predictors (the "endowment effect"). The second component $C = E(X_A)'(\beta_A - \beta_B)$measures the contribution of differences in the coefficients (including differences in the intercept). The third summand $I = [E(X_A) - E(X_B)]'(\beta_A - \beta_B)$ is the interaction term accounting for the fact that differences in endowment and coefficients exist simultaneously between the two groups (Jann 2008:3).

The main limitation to Blinder – Oaxaca has been the need to have only two groups to compare. However, the comparison of thermal and hydro plants contribution to electricity security of supply is the basis of this research as other renewables and alternative sources of power generation are yet to be introduced in any significant amounts. This makes its application very relevant.

5.15 COMPARATIVE LEGAL METHODOLOGY

The research undertakes a rigorous systematic analysis, exposition and critical evaluation of legal rule, legal principle, legal concept or doctrine (i.e. legal fact) surrounding electricity value chain. Based on this analysis, the conceptual basis of the legal rule, principle or doctrine that may forward some proposals for reforms would be highlighted. The comparative legal research methodology will accordingly provide the bases: (i) to initiate acquaintance with a foreign law, (ii) to animate and modernise the study of private law of a country, (iii) to prepare an internal law by knowing the way in which the legislature from other jurisdictions has carried out reforms, and (iv) to study law ‘common to all’ especially in relation to investment law which goes with managing investments into the electricity value chain.

The research adopts a pragmatic worldview to case study in keeping with Yin (2009) in the collection of data and case laws relevant to the research (e.g. the Africa and Middle East Resources Investment Group LLC (AMERI) and Balkan Energy agreements, contracts and cases). It begins by using the analytical approach to support the process of micro and macro -comparison of specific legal systems and institutions or problems in the Ghanaian case on one hand and other petroleum regimes and power markets. The documentation analysis therefore follows from the review of the literature on comparative petroleum law, power market regulation, economics and taxation in addition to the analysis of legal regimes. This is followed by the use of the functionalist method in legal comparative law. Following the theory of Zweigert and Kotz (1998) the functional question is first defined and the ways the legal regimes in Nigeria, China, the UK, Norway among others as the research samples to solve these functional problems. In this research the functional elements are risks, resource control and profit allocation. By examining the risks the following four issues will be considered.

Since a critical criterion in defining the electricity security of supply is the availability and management of input supply (IEA 2016) and in Ghana with its growing gas reserves, the first legal issue to examine, is the role of the government in the high end risk of oil and gas discovery in terms of financing, information and technology in keeping with Woodhouse (2007). Of particular interest are the stability guarantees, their form and quality. In addition is the nature of government underwriting of risks in the contracts and the degree of effectiveness. The objective is to ascertain how the petroleum regime mitigates political and some aspects of the financial risks expected in the exploration stage. In addition is the risk involved in the development of the field which may require the unitisation of operations which require that allocation of budgetary risks to minimise liquidity challenges while containing costs is also analysed.

The second is the issue of ownership and control over the produced crude or gas including its marketing. This assesses the form of oil or gas holding either in kind or in cash and the payment for the costs likewise in kind or in cash. The last is the issue of profit allocation. The section assesses how the cost oil and profit oil is defined in addition to other elements such as domestic obligation, payment of tax and the form it takes and the flexibility in the fiscal design.

This is followed by listing the similarities and differences between these regimes on one hand and the Ghana's petroleum legal regime on the other. The aim is to assess the degree at which the Ghanaian petroleum regime provides adequate guarantees (Wäelde and Kolo 2000). The evaluation is ascertained by establishing whether any hypothesis established can be proven or disproven and to decide what conclusions and/or recommendations can be formulated based on the finding (De Jong et al 2002).

The research combines a number of familiar elements in legal research. It is partly historical and partly comparative; it uses a case study approach to examine groups of countries from a particular region, and it analyses important power market reforms in detail. While the research is focussed on energy investment in the power sector, there are inevitably many references to institutions, concepts, principles and procedures common to international investment law in general. International investment law and its institutions therefore have significance for an understanding of the current interplay between contract-based and treaty-based mechanisms in establishing and maintaining long-term stability in investor-state relations in the international energy industry which Ghana has benefited from. For example, in the recent Ghana and Ivory Coast Dispute (2017) adjudicated by the Special Chamber of the International Tribunal of the Law of the Sea (ITLOS) in Hamburg Germany on 23rd September, 2017, secured Ghana's boarders with Ivory Coast toward the development of Ghana's gas and oil fields with its western neighbour.

Riding on the shoulders of Cameron (2010), two key challenges face any researcher in this area. The first concerns the available data. The contracts which investors and states reach on a particular investment will sometimes be in the public domain but often they are not or are hard to obtain. There may also be barriers imposed by the language of the contract. In the event of a dispute between the parties that is subject to arbitration, the proceedings will normally be heard in private and if there is an award on the merits, it is not certain that it will be published (with the exception of International Centre for Settlement of Investment Disputes(ICSID)).

Two key sources of data are therefore available only on an incomplete basis, which recommend caution in making generalisations that rely upon legal materials in the public domain or accessible to the researcher through other means. A second challenge arises from the fact that the application of international investment law is heavily dependent upon the facts of a particular case and indeed on the wording of the particular BIT or MIT that provides the legal frame of reference. The diversity of circumstances and heterogeneity of international investment agreements means that an empirical, case-by-case approach (the method of detail) is unavoidable if one seeks to identify trends. However, it is generally agreed that patterns are emerging in the development of international investment law. The references to these challenges are discussed in chapters 6 and 7.

5.16 CHAPTER SUMMARY

This chapter has discussed data considerations and analysis procedures adopted in this thesis with particular emphasis on data collection procedures and the method of analysis in achieving the thesis objectives. First, it attempted to describe the data and sample taken. It is followed by the measurement of dependent and independent variables and their sources were comprehensively explained. The weighting and structuring methods are then discussed. Second, the independent variables were discussed. The linear GMM model is suggested to test the robustness of the results. The result from the statistical tests employed will be discussed in the next two chapters.

There remains the question of the use of the law to ensure electricity security of supply. The principal means of checking that security levels are appropriate in social terms is to convert risks into costs, i.e., in particular, into compensable damages. Claims for damages thus not only have the individual related function of compensating the injured parties, but also—if necessary, determined through the premiums for insurance cover—the economic function of bringing the liable party to a new optimisation of services offered.

Under the economic theory of law the system of liability is accorded an importance going beyond the compensation of the individual case, both in terms of service content and price level. The system of official supervision, in line with its objective of avoiding damages in the public interest, takes precedence over the rules on the settlement of individual damages.

The system of official supervision is, in particular, intended to prevent damages which, due to their nature or scale, are not compensable. Nonetheless, a wide range of damages can be compensable. The question arises whether, as a result of the transition to the competitive system, official precautionary measures (supervisory legislation) and the legal provisions for subsequent protection require adaptation or revision. These measures will complement the findings from the outcome of the econometric estimations.

CHAPTER 6

UNIVARIATE ANALYSIS

6.1 INTRODUCTION

This chapter uses descriptive statistics to compare changes in the availability of power generation trends in Ghana from 2007 to 2016. The chapter seeks to achieve three objectives. The first is to examine the differences in the measures of electricity security of supply (ESoS) between the thermal and hydro sources of power generation. The second is to ascertain if the IPPs and the state-owned generators contribution to electricity security of supply report the same level and pattern of contribution in Ghana. The third is to identify the implications of the findings for the power sector management in Ghana.

6.2 COMPARATIVE DESCRIPTIVE STATISTICS FOR POWER PRODUCERS

A summary of the descriptive statistics of the actual power produced by generators without taking into account their installed capacity is presented in Table 6.1. The table reports the mean, minimum and maximum values for individual producers over the sample period 2007 to 2016. The main producer in gigawatt-hours on average has been the Akosombo dam and or from other hydro sources over the period of the study.

These firms are state-owned generators. This is followed by the thermal plants mainly TAPCO and TICO owned by private investors or independent private producers. On average 65 per cent of the output over the period of study is generated by state-owned firms as against IPPs.

From the table, the share of production by IPPs has increased significantly from 2011. CIPREL is an exporter from Cote d'Ivoire or represents imports by VRA.

Table 6.1

Actual Production from 9 Power Generation Firms from 2007-2016 in gigawatt - hours (GWh)

	GENERATOR	2007	2008	2009	2010	2011	2012	2 013	2014	2015	2016	Average
1	AKOSOMBO	3,104	5,254	5,842	5,961	6,495	6,950	6,727	6,509	4,156	3,854	5,485.20
2	KPONG	623	941	1,035	1,035	1,066	1,121	1,144	1,148	819	763	969.50
3	TAPCO	1,521	874	453	1,234	1,137	1,061	1,783	890	1,784	1,204	1,194.10
4	TICO	1,417	1,063	1,040	1,160	657	1,168	1,032	712	1,336	1,926	1,151.10
5	TEMA REV. PLANT/ TT1PP	162	85	570	591	559	622	475	697	541	178	448.00
6	TT2PP/ERP	80	45	20	28	50	141	94	233	216	25	92.20
7	MRP/ AMERI/ KARPOWER SHIP	38	46	18	20	12	20	20	195	170	3,055	359.40
8	ASOGLI/ CENTI/ KSI/KPONE THERMAL	33	16	20	138	1,224	942	1,148	1,478	1,502	988	748.90
9	CIPREL	435	275	198	106	81	126	27	51	233	511	204.50
	Average	823.7	955.4	1,021.8	1,141.4	1,253.4	1,350.3	1,383.3	1,323	1,195.5	1,389	
				Source: Computed by the Author								

6.3 PERFORMANCE OF THE ELECTRICITY SECTOR

Table 6.2 below translates Table 6.1 into electricity security of supply (ESoS) units.

Table 6.2

Firm –level ESoS from 2007 to 2016

	GENERATOR	2007	2008	2009	2010	2011	2012	2 013	2014	2015	2016	Average
1	AKOSOMBO	3,043	5,151	5,727	5,844	6,367	6,814	6,595	6,381	4,075	3,221	5,321
2	KPONG	3,894	5,881	6,469	6,469	6,662	7,006	7,165	7,175	5,119	4,768	6,059
3	TAPCO	4609	2,648	1,373	3,739	3,445	3,215	5,403	2,697	5,406	6,390	3,893
4	TICO	6,441	4,832	4,727	5,273	2,986	5,309	4,690	4,691	3,236	4,048	4,872
5	TEMA REV. PLANT/ TT1PP	475	575	225	250	150	250	250	2,437	515	5,707	1,053
6	TT2PP/ERP	1,473	773	6,091	5373	5,081	5,655	4,318	6,336	4,918	1,413	4,143
7	MRP/ AMERI/ KARPOWER SHIP	1,616	909	404	566	1,010	2,820	1,899	4,460	4,320	4,646	2,265
8	ASOGLI/ CENTI/ KSI/KPONE THERMAL	660	320	400	690	6,120	2,889	3,522	4,533	2,968	3,031	2,513
9	CIPREL	2,175	2,500	1,980	1,325	1,157	1,422	540	1,020	860	2,323	1,530
	Average	2,708	2,621	3,044	3,281	3,665	3,931	3,819	4,253	3,581	4,164	
				Source: Computed by the Author								

This means the actual production in gigawatt- hours are changed into megawatts and divided by its installed capacity over the period. Table 6.3 summarises the distribution of the ESoS measured over the period from 2007 to 2016.

Table 6.3

Summary Descriptive Statistics of ESoS

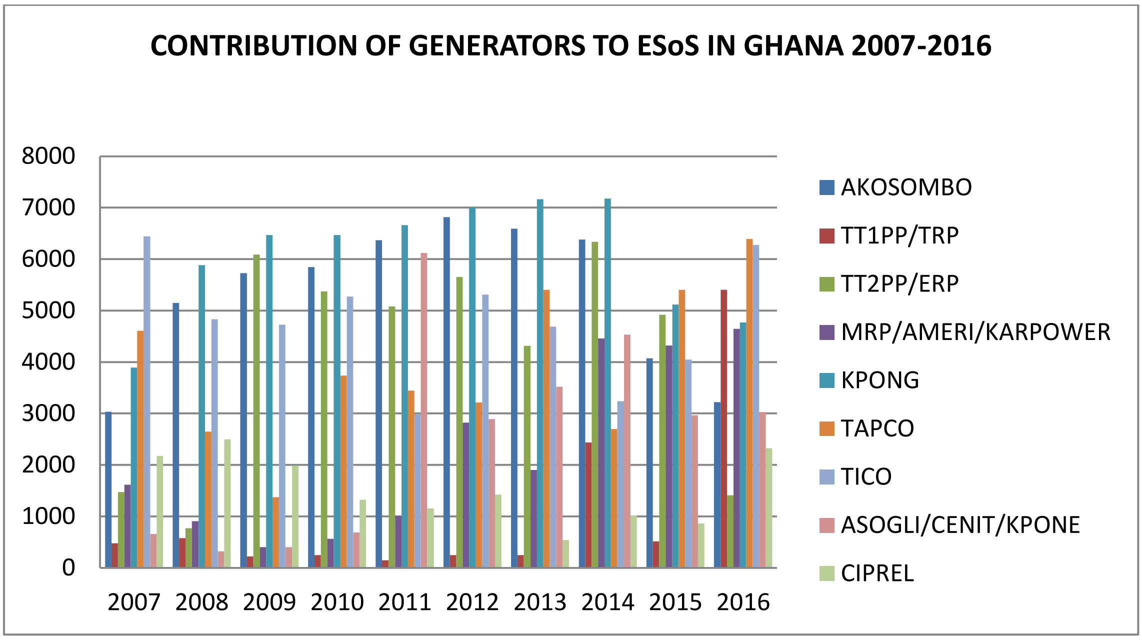
Variable	Obs	Mean	Std. Dev.	Min	Max
2007	9	2708.53	1976.23	475	6440.91
2008	9	2621.04	2172.57	320	5881.25
2009	9	3034.01	2666.43	225	6468.75
2010	9	3280.93	2558.88	250	6468.75
2011	9	3664.55	2513.11	150	6662.5
2012	9	3931.17	2379.92	250	7006.25
2013	9	3818.63	2489.61	250	7150.00
2014	9	4253.03	2083.66	1020	7175.00
2015	9	3580.97	1791.23	515	5406.06
2016	9	4163.96	1757.02	1412.7	6390.91
Average		3506.68	1747.86	1053.47	6059.91
Software Used: STATA 12					

It shows that the year with lowest mean ESoS is 2008. The highest was in the year 2014. The year with the highest volatility in plant production on average was in 2009. Overall the ESoS has improved from 2,621.04 in 2008 to 3,931.17 in 2012. It declined to 3,818.63 in 2013 and recovered in 2014 to 4,253. 03. It fell to 3,580.97 in 2015 and increased to 4,163.96 in 2016 but below the 2014 level.

Figure 6.1 shows the distribution of the ESoSs across the 9 firms for the period 2007 – 2016. For all the column charts shown, the first five firms on the horizontal axis are state-owned generators in Ghana. The remaining four firms are privately-owned independent power projects (IPPs) in Ghana. The figures show that the contribution of the Akosombo dam is still significant but has been declining in performance relative to the growing contribution to electricity supply from other thermal sources. In terms of ownership the state-owned generation firms' contributions are still significant relative to the private power producers. The significance of the IPPs is shown from 2013 to 2016.

Figure 6.1

Contribution by Generators



Source: The Author

Figure 6.1 shows that the thermal plants notably TAPCO and TICO have contributed consistently to Ghana's ESoS over the period. Kpong Hydro has also been very efficient and effective given its installed capacity.

Tables 6.1 and 6.2 become meaningful when they are analysed with the comparative investments by governments relative to development agencies and IPPs as shown in Figure 6.2. In Chapter 2, the comparative analysis of government investments into installed capacity in Sub-Saharan Africa was presented.

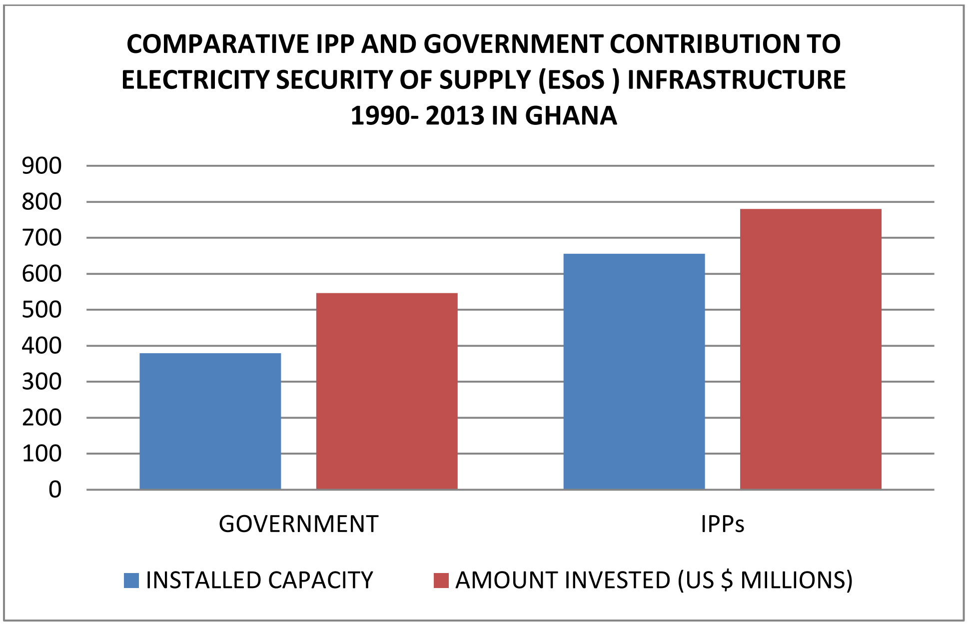
The comparative analysis in this chapter takes into account two other countries because they have adopted the same model in the development of their power sector. The countries are Uganda and Nigeria. South Africa is included given its level of economic development and the extent to which it has leveraged on

IPPs who now drive the potential increase in the ESoS in the Ghanaian power sector.

Figure 6.2 shows the comparative contribution of IPPs and Government investments in generation capacity from 1990 to 2013 in Ghana. IPPs have increased their investments in monetary and physical generation capacity by 73 per cent and 42.7 per cent respectively over the government's investments in generation capacity over the period.

Figure 6.2

Relative IPPs and Government of Ghana's Investments into power sector infrastructure from 1990 to 2013

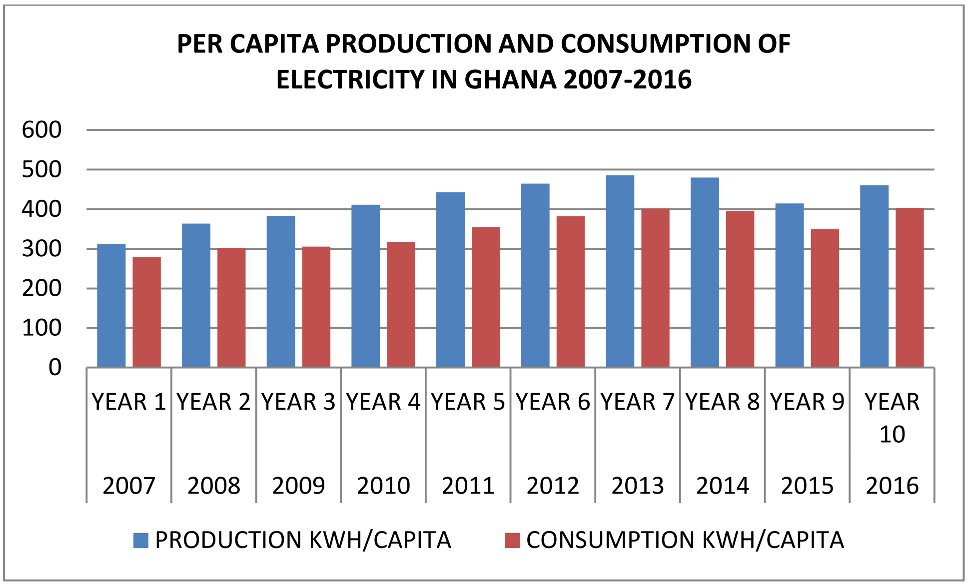


Source: Adapted from Eberhard et al 2016

Against this background are the discrepancies between production and consumption per capita. These reflect the losses and inefficiencies in the distribution of power as shown in Figures 6.3 and 6.4 below.

Figure 6.3

Electricity Consumption Gap in Ghana

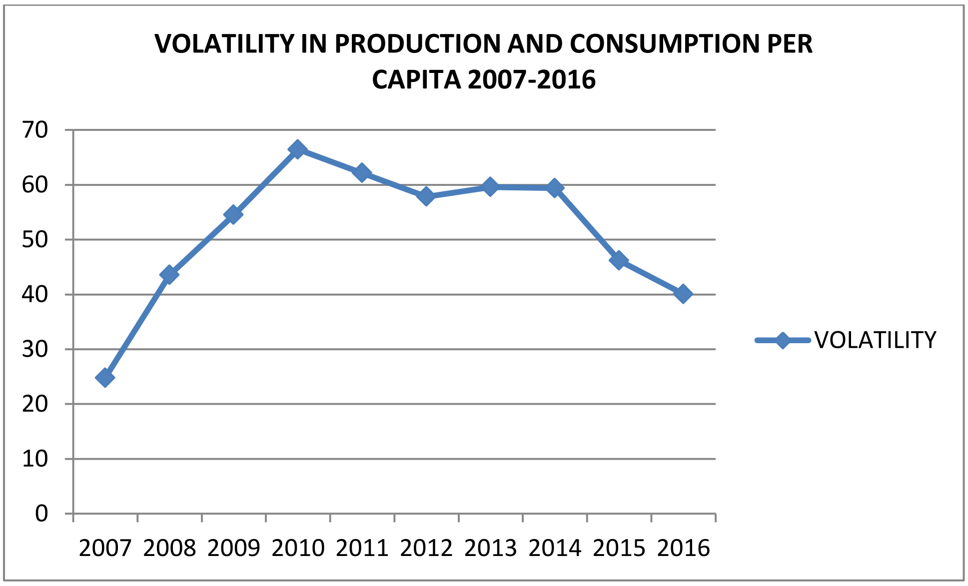


Source: The Author

This is partly measured by the volatility in the production and consumption per capita as shown in Figure 6.4 below. The trend shows that the gap has been consistent between 25 per cent and 35 per cent from 2007 to 2016. This gap is very high by all international standards(Eberhard et al 2016) as they reflect the ability of the industry to recover revenue from power generated, and signal IPPs the potential revenue risks that potentially exist in the industry (Di Bella and Grigoli 2017).

Figure 6.4

Volatility in production and consumption per capita differential



Source: The Author

The degree of losses is also presented in Figures 6.5 and 6.6. The losses comprise of technical and commercial losses. These losses are caused by poor network, transmission infrastructure, while the commercial losses are due to distribution failures like poor metering, billing and power loss through illegal connections.

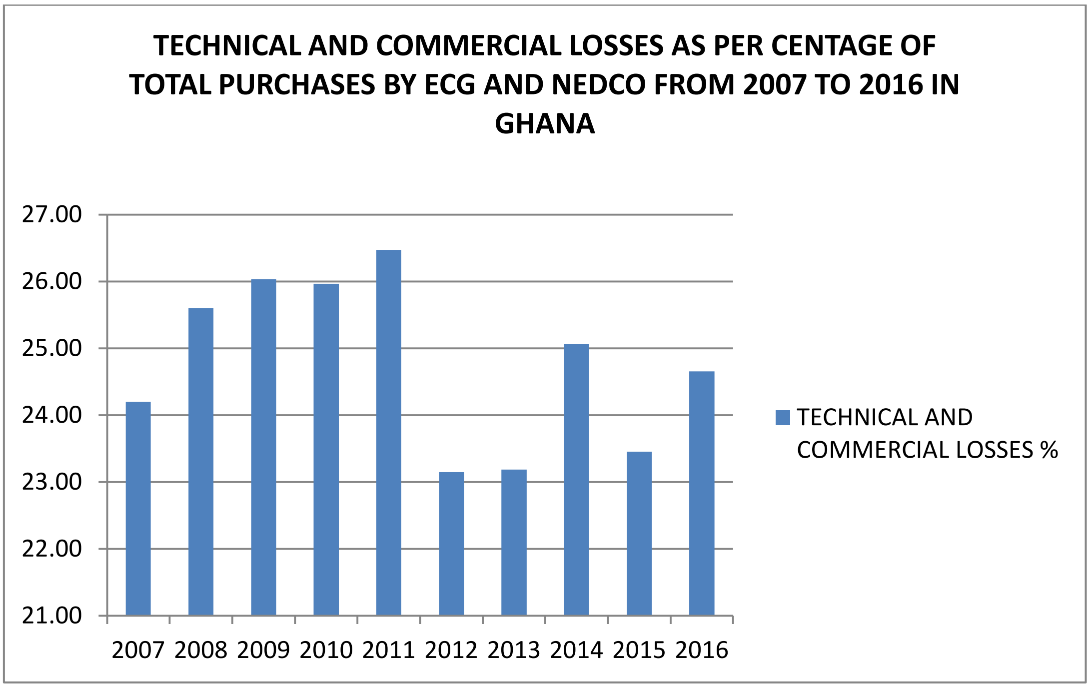
Atems and Hotaling (2018) who examined the impact of electricity generation on economic growth using a panel 174 countries found a negative relationship between electricity loss and economic growth. They argue that such a relationship has significant implications for the future of electricity generation as well. They stress that losses create a vicious cycle where the systems are compromised by the stress placed on it by the number of unmetered users. They argue that utility providers lose revenue and therefore are unable to make needed investments to upgrade the transmission and the distribution infrastructure. Empirically, Jamil (2013) who studied relationship between electricity shortage, price and electricity theft in Pakistani, provides an insight into the psychology of those who steal power and shows that the individuals stealing electricity have no incentive to be conservative in their electricity use, leading to inefficient use, and utility providers end up relying on subsidies from the government, thereby crowding out private investment and economic growth.

Transmission losses are physical and technical. Nepal and Jamasb (2013) show that, unplanned interruptions due to system breakdowns and increased planned outages due to maintenance and upgrades are more frequent in old and poorly maintained networks. They require investments into the grid system to ensure efficiency. Because transmission is always taken as a monopolist in the unbundling process, there is the need to ensure that sustained investments are made by the government. Nepal and Jamasb (2015) argue that, in the absence of regulatory interventions, network companies face low incentives for internal efficiency and greater incentives for rent seeking, leading to distortions in allocative efficiency. Technical losses have on average stood at 4 per cent of net power generation from 2007 to 2016 as shown in Figure 6.9. Investments in transmission should be geared towards not only relieving congestion by adding transmission capacity, but also at modernising and increasing the resilience of the grid. Larsen et al (2017) argue that, the amounts invested, while a useful indicator of the state of the network, are not a satisfactory measure as a component is not restored to and as good as new condition from a reliability perspective. The age of the grid seems a more appropriate indicator of current performance and potential problems. In particular, it also provides an indication of the investments that will be required in the medium to long term to maintain reliable transmission (Eberhard et al 2011).

Distribution losses are largely administrative and require that credible measures are in place to make the application process for power connection simple and applicants are billed correctly. Prepaid meters limit losses but where users are able to by-pass the metering process, it requires monitoring to have these offenders identified and charged with heavy penalties to deter others. Another major source of power losses which is also technical in the area of power distribution is transformers breaking down or being overloaded. These transformers also have low capacitors to absorb minor disturbance which also give rise to frequent power outages. This creates challenges to structural supply security as there has been a failure to develop the necessary grid capacities (and therefore grid redundancy decreases) (Energieinstitut 2012) and, consequently, tend to increase the number of outages (Röpke 2012).

Figure 6.5

Technical and Commercial Losses from 2007 -2016

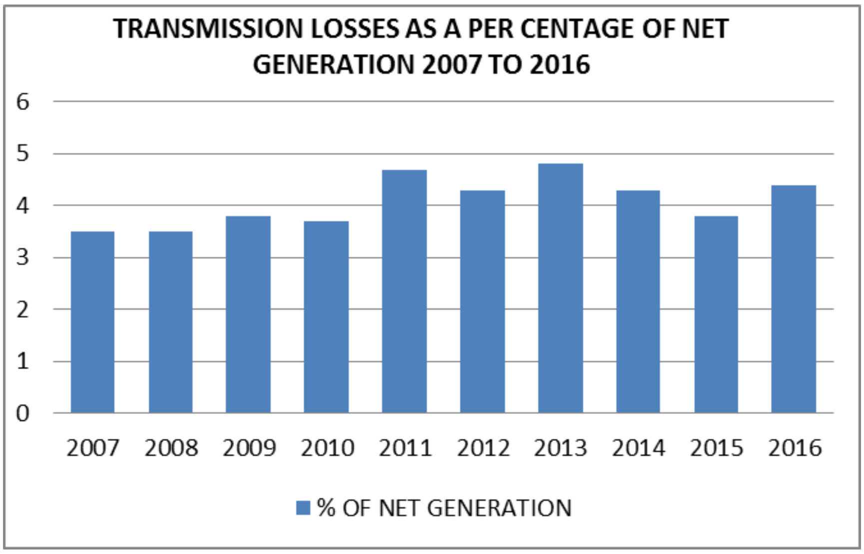


Source: Energy Commission and the Author's Illustration.

The ageing grid also has an effect on the distribution sector. An analysis of the quality of distribution service by Ghana's Energy Commission (2017) shows an increasing trend in declining service quality as shown below.

Figure 6.6

Transmission Losses as a percentage of Generation from 2007 to 2016



Source: The Author and Energy Commission (2017)

6.4.0 SERVICE QUALITY INDICES AND ELECTRICITY SECURITY OF SUPPLY

The Energy Commission began the measurement of service quality in electricity in Ghana from 2015. This activity requires the measurement of key reliability indices including the system average interruption index (SAIFI), system average interruption duration index (SAIDI) and cumulative average interruption duration index (CAIDI).

Table 6.4

Service Quality Index in Ghana (2015 and 2016)

Reliability Index System Average Interruption Frequency Index(SAIFI)	Operational Area	Regulatory Benchmark (Per LI 1935)	Electricity Company of Ghana (ECG)	
SAIFI (Interruptions/ Customer). This is the number of times that a customer is interrupted during an operational year		Maximum number of Outages per year	2015	2016
	Metro	6	18	27
	Urban	6	19	39
	Rural	6	27	27
System Average Interruption Duration Index (SAIDI)	Operational Area	Regulatory Benchmark (Per L.I. 1935) Maximum number of outages per year	Average Values	
			2015	2016
SAIDI (Hours/Customer) = Sum of all customer Interruption Durations / Total Number of Customers Served This is a measure of the average duration of interruptions recorded for the distribution system during an operational year	Metro	48 hours	40	60
	Urban	72 hours	34	67
	Rural	144 hours	51	72

Source: Energy Commission of Ghana (2017)

Table 6.4 (Continued)

Cumulative Average Interruption Duration Index (CAIDI) CAIDI = SAIDI/ SAIFI	Operational Area	Average duration of outage permitted per year for interrupted customers only	2015	2016
CAIDI = Sum of all customer Interruption Durations/ Total Number of Customer Interruptions. This is a measure of the average duration of interruptions for only customer interrupted during an operation.	Metro	8 hours	2	2
	Urban	12 hours	2	1
	Rural	24 hours	2	2

Source: Energy Commission of Ghana (2017)

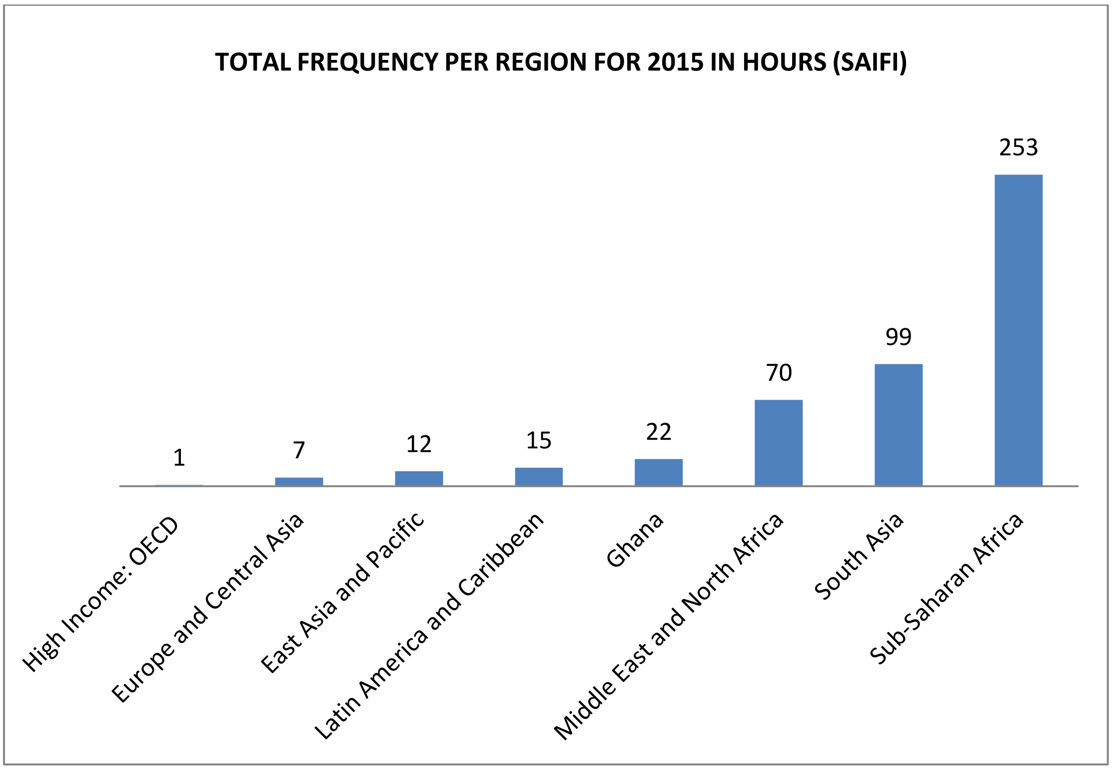
In keeping with Röpke (2012) the term "security of electricity supply" is used in a purely technical sense. Beginning with the view that a low level of supply security is associated with a high number of supply interruptions and is therefore costly for society, a reliable grid-bounded electricity supply can be seen as an important economic good, meaning that provision of the grid, a natural monopoly, is of particular importance. Various indices measure the technical supply security level. In general, the most important dimensions of technical (supply) security are frequency, duration, and extent of supply interruptions.

The level of supply security is approximated with the SAIDI, an internationally employed reliability index that is a part of the German Electricity Network Access Ordinance (Anreizregulierungsverordnung, A RegV). The SAIDI describes the quality of supply security by measuring the average amount of time per year that the power supply for a customer is interrupted (CEER 2008). The SAIDI can be interpreted as a proxy for the (technical) level of supply security (Röpke 2012).

Several observations emerge looking at SAIDI and SAIFI across economies. Recent empirical study by Arlet (2017) who examined 190 counties shows that outages greatly vary from one country to another. Comparatively, in 2015, for example, customers in nearly 50 countries experienced less than one hour of blackouts. These economies include the likes of Germany, Singapore or Costa Rica. On the upper boundary, power was interrupted for over 1,000 hours in 2015 in Comoros, Eritrea, Iraq, Nigeria, Pakistan, South Sudan and Swaziland. Owing to such extreme cases, the 2015 global SAIDI average was 148 hours compared to a median of 3.5 hours. Moreover, the 38 countries where no SAIDI/SAIFI data are available have, on average, more than twice more outages according to the Enterprise Study by the World Bank (Arlet 2017). This study did not include Ghana, but further comparative data indicates that the security of supply using the Ghanaian SAIDI is comparative good by Sub-Saharan standards but poor by global standards as shown in Figures 6.8 below.

Figure 6.7

Comparative SAIFI performance of the Ghanaian Power Sector



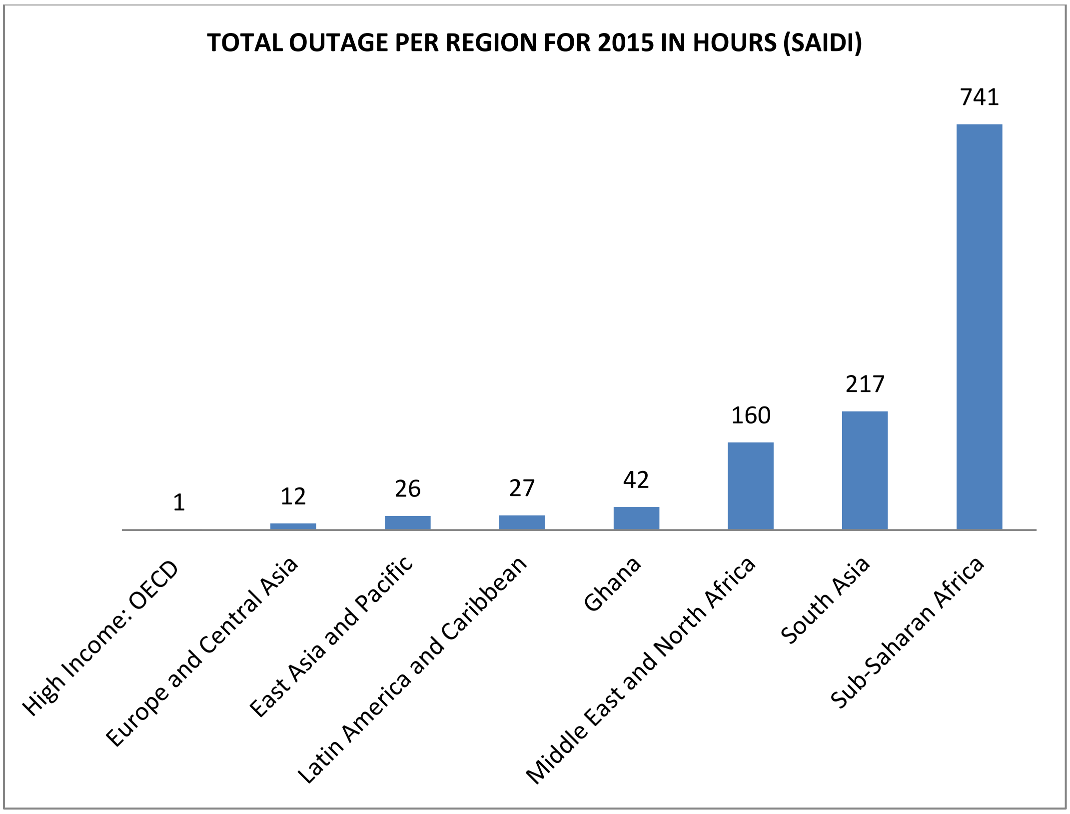
Source: Adapted from Arlet (2017); Energy Commission (2017) and the Author's Calculations.

Figure 6.7 shows the comparative SAIFI performance of the Ghanaian power sector. Ghana compares favourably to Middle East and North Africa, South Asia and most of the Sub-Saharan African countries. The power sector's performance was below that of high-income OECD countries, Europe and Central Asia, East Asia and Pacific and Latin America and Caribbean countries on average. However, a critical look at the Ghanaian regulatory standard based on LI 1935 Electricity Supply and Distribution (standards of performance) Regulations 2008, which sets the regulatory benchmark at a maximum of 6 outages per year, the performance of the sector was poor as deviation was over 266 per cent.

An analysis of the 2016 figure showed a worsened situation with the SAIFI (Figure 6.7) increasing from 22 to 31 on average or a little over 300 per cent away from the regulatory benchmark.

Figure 6.8

Comparative SAIDI performance of the Ghanaian Power Sector



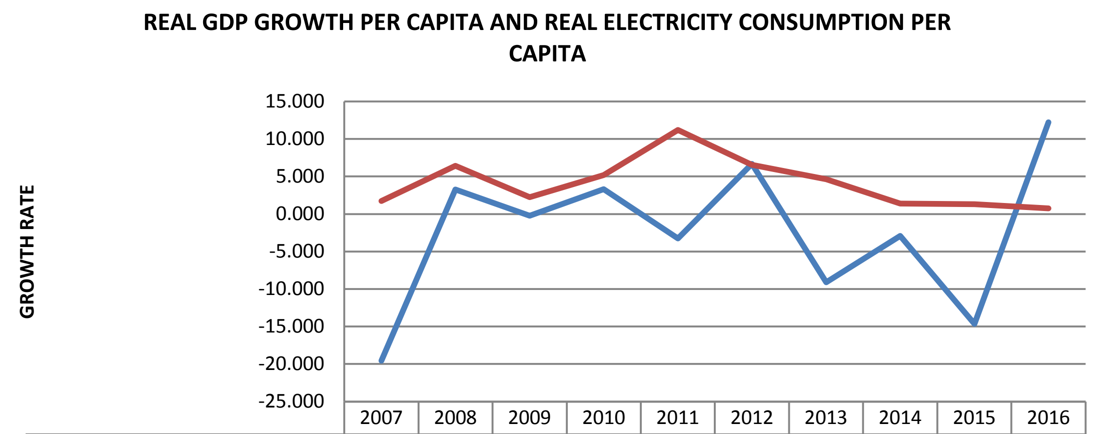
Source: The Author

The comparative SAIDI performance of the power sector in Figure 6.8 shows that Ghana compares favourably to the Middle East and North Africa, South Asia and most of the Sub-Saharan African countries. The power sector's performance was below that of high-income OECD countries, Europe and

Central Asia, East Asia and the Pacific and Latin America and Caribbean countries on average. However, a critical look at the Ghanaian regulatory standard based on LI 1935, which sets the regulatory benchmark at a maximum of range of 48 hours for metropolitan customers who have greater political voice per year, the performance of the sector was on average 42 hours taking into account the urban and rural customers. However this performance level worsened to 66 hours based on ECG's performance representing a deviation of 37.5 per cent. Operating conditions such as poor weather also increase component failure rate, particularly in the presence of ageing components (Larsen et al 2017) and low quality installed grid equipment.

Figure 6.9

Real GDP Growth per capita and Real Electricity Consumption per capital in Ghana



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
ELECTRICITY CONSUMPTION GROWTH	-19.536	3.260	-0.210	3.303	-3.262	6.700	-9.108	-2.915	-14.666	12.240
GDP GROWTH PER CAPITA	1.747	6.427	2.231	5.208	11.205	6.569	4.637	1.394	1.292	0.761

Source: Economic Research Federal Reserve Bank of St. Louis USA and the Author's Calculation

Figure 6.9 shows that growth in real electricity consumption per capita improved from a negative growth in 2007 over 2006 into a positive growth in 2008 to 2010 and again took a negative trend in 2011, but Ghana experienced the highest real GDP growth due to the initial production of oil from the Jubilee field. Excluding oil, would have meant an equal decline in non- oil GDP level. The years 2012, 2013, 2014 and 2015 had negative growth in electricity consumption. The GDP growth has also been falling. In 2016 saw a positive growth in electricity demand but structural issues have seen stagnation in the growth of Ghana's real GDP at 0.761 per cent.

This confirms the findings in the recent study by Arlet (2017) and Atems and Hotaling (2018) about the consequences of electricity security of supply on real GDP growth in many developing countries. They find that availability and the security of supply impacts positively on real GDP growth in many developing countries. Likewise, Pelemis and Dagoumes (2013) found that the causal relationship between electricity consumption and economic growth in Greece is bi-directional.

This brings to question the management of the utility companies and their role in the entire value chain. Critically, government interference affects the quality of management and their ability to put in place steps to improve the utility companies. With the distribution company entering into direct contract with IPPs for power generation also requires the proper assessment of performance of the IPPs as such agreements impact on the finances of the utility firms in the value chain.

Table 6.5

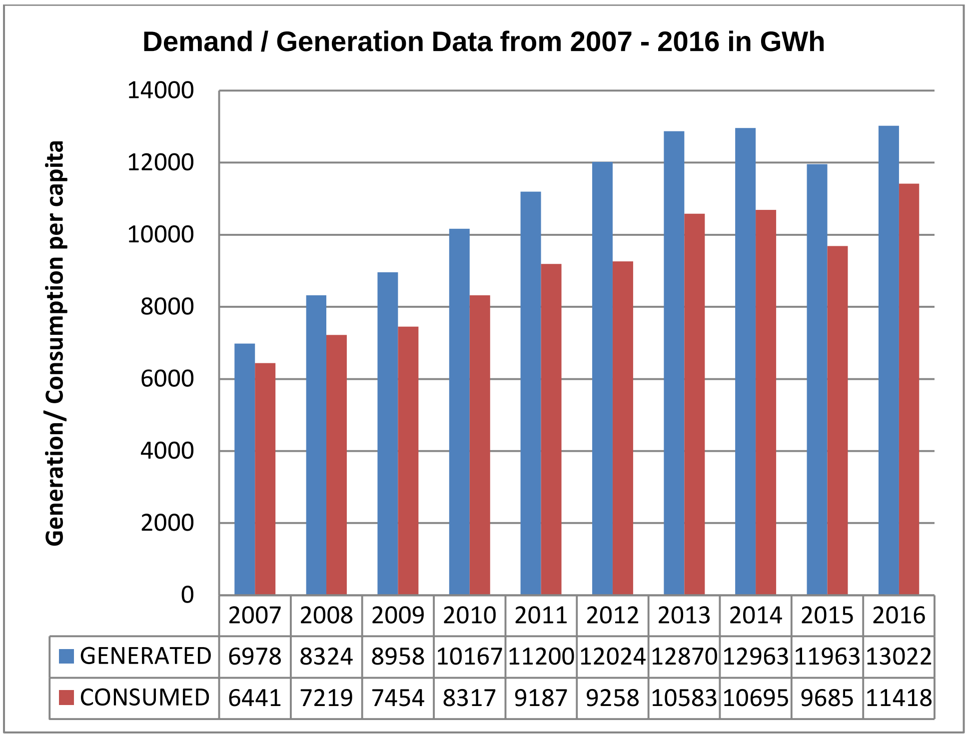
Two sample t-test with equal means between consumption and generation per capita in gigawatt hour 2007 to 2016

Generation per capita in GWh	Consumption per capita in GWh	Difference	t-value	P-value	Mean
10, 799.8	9,025.1	1,774.1	2.0886	0.0512	9.912.75
Software Used: STATA 12					

Further analysis using the two sample t-test with equal means shows that the difference between consumption and generation on gigawatt- hour per capita is significant at the 10% level and not at 1% and 5% levels. Eberhard et al 2011 draw our attention to the structure of demand in capacity short economies. They stress that a distinction has to be made between effective demand and suppressed demand which is through delayed metering and energising of power lines. The need for easy process of connection is also confirmed by Geginat and Ramdho (2015) as a good measure of power sector performance (Arlet 2017). These findings reinforce the effects of transmission losses on electricity security of supply as presented in Figure 6.6.

Figure 6.10

Demand and Consumption per capita from 2007 to 2016



	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
GENERATED	6978	8324	8958	10167	11200	12024	12870	12963	11963	13022
CONSUMED	6441	7219	7454	8317	9187	9258	10583	10695	9685	11418

Source: The Author and Energy Commission (2017)

Figure 6.10 above shows that it is supply determining demand in Ghana. This means that regulatory measures should also be geared towards minimising losses as presented in Figure 6.6. Again it also follows that the political economy relating to revenue from the sector is not positive as few people are made to bear the losses. Again the losses have to be paid for which also increases utility bills imply low value for money, economic loss and thereby the security of supply. Röpke (2012) again shows that because SAIDI is a component in the calculation of value of the security of supply, measures to improve it leads to quality improvement levels in the security of supply.

6.5.0 UNIVARIATE ANALYSIS: THE ESoS

This section examines the correlation between the ESoS and the individual variables that affect the level of electricity security of supply which include size, financial efficiency, sustainability practices, ownership and regulatory practices.

6.5.1 CORRELATION: ELECTRICITY SECURITY OF SUPPLY AND REGULATION AND FIRM-LEVEL VARIABLES

From the OLS diagnostic tests shown in Appendix 5.2, the data is found to be normal and therefore the Pearson product-moment correlation matrix is used to ascertain if there is a possibility of multicollinearity. The Table 6.6 below shows the correlation that exists amongst model variables.

The strength of the relationship between the ESoS and the drivers in Ghana provides an insight into how firm-level risk taking and regulatory activities affect each other. The Pearson product correlation matrix which assumes normality of data is presented below.

Table 6.6

Pearson Product-Moment Correlation Matrix

(1)	ESoS (2)	REG (3)	FINEFFECT (4)	SIZE (5)	SABILITY (6)	OSHIP (7)
ESoS	1.000					
REG	0.1885	1.000				
FINEFFECT	0.1797	0.7083	1.0000			
SIZE	0.5302	0.2387	0.1533	1.0000		
SABILITY	0.4779	0.0679	0.0837	0.4066	1.0000	
OSHIP	0.1721	0.0817	0.0990	0.0900	-0.0860	1.0000
	ESoS- Electricity Security of Supply; REG- Regulatory Measures; FINEFFECT- Price of Electricity; SIZE – Plant Investment size; SABILITY- Sustainability ; OSHIP- Ownership.					
	Source: STATA 12					

The simple correlation matrix in Table 6.6 shows five measures of regulation and firm –level risk activities and the ESoS. The correlations in column 1 of Table 6.6 suggest that the ESoS is positively correlated with regulations, prices of electricity, size of plant and investments, sustainability measures and ownership of the plants. The column 6 of Table 6.6 for example, shows a negative correlation of 0.086 between sustainability and ownership. The correlations reported in column 2 range from 0.17 to 0.53, indicating that various measures captured relate differently with the ESoS.   Correlations reported in columns 3 to 7 of Table 6.6 also range between -0.08 to 0.23. The findings suggest that the firm-level variables also correlate differently with the regulatory variables.

The results suggest that multicollinearity might not be a problem because the correlations are less than 0.8 (Gujarati and Porter 2009). Again, Table 6.6 only showed the association between the ESoS and the firm-level and regulatory variables which might be suggestive. Unless causality is established as will be discussed in chapter 7, such results are rarely compelling (Wooldridge 2013). The Spearman Correlation which does not assume normality is presented in Table 6.7 below.

Table 6.7

Spearman Rank Correlation Matrix

(1)	ESoS (2)	REG (3)	FINEFFECT (4)	SIZE (5)	SABILITY (6)	OSHIP (7)
ESoS	**1.000**					
REG	**0.1882**	**1.000**				
FINEFFECT	**0.1718**	**0.7809**	**1.0000**			
SIZE	**0.5131**	**0.2998**	**0.2081**	**1.0000**		
SABILITY	**0.4259**	**0.1199**	**0.0956**	**0.3576**	**1.0000**	
OSHIP	**0.1692**	**0.0854**	**0.0934**	**0.0977**	**-0.1575**	**1.0000**
	ESoS- Electricity Security of Supply; REG- Regulatory Measures; FINEFFECT- Price of Electricity; SIZE – Plant Investment size; SABILITY- Sustainability ; OSHIP- Ownership.					
	Source: STATA 12					

They show the same pattern except that the product correction matrix shows a stronger relationship between the regulatory and firm-level factors than that presented under Spearman rank correlation matrix. There is a negative relationship between sustainability and ownership because of the increasing reliance on imported gas which has affected the generation of many of the IPPs notably Asogli and the Tema plants.

The rule of thumb for checking problem of multicollinearity is when the correlation is greater than 0.7 (Tabachnick and Fidell 1996). Again, a sample correlation of more than 0.8 is evidence of severe collinearity (Gujarati and Porter 2009).The results suggest that multicollinearity might not be a problem because the correlations are less than 0.8 (Gujarati and Porter 2009).

6.5.2 SAMPLE T-TESTS OF THE ESoS

Again an obvious question that arises from Tables 6.1and 6.2 above is whether or not the differences in ESoS by hydro and thermal generation shown are statistically significant. The independent samples t-test is used to examine the differences in ESoS variables for both hydro and thermal generators from 2007 to 2016 using the average of the variables.

The results in columns 1 through 3 of Table 6.8 suggest that the significant influence of hydro generation has been neutralised by the thermal sources. Except for the years 2007, 2015, 2016, column 5 of Table 6.8, which reports the p-values, suggests that the ESoS gaps which exist between the hydro and thermal power generation firms from 2008 to 2014 are statistically significant.

In 2008, the reported difference was statistically significant at the 5% and 10% levels. In 2009 and 2011 the differences are statistically significant at the 10% level. In 2012, the difference in ESoS was statistically significant at the 5% and 10% levels. The overall average difference in ESoS from 2007 to 2016 was statistically significant at the 5% and10% levels.

Table 6.8

T-tests of Differences in Means of the ESoS of 9 sources of Electricity Supply in Ghana from 2007 -2016

T-test					
	(1)	(2)	(3)	(4)	(5)
Year	Hydro	Thermal	Difference	t-value	p-value
2007	3463.945	2492.69	971.24	0.5873	0.5754
2008	5516.115	1793.87	3772.24	3.0509	0.0186
2009	6098.10	2171.42	3926.68	2.2592	0.0584
2010	6156.435	2459.36	3697.08	2.1869	0.0650
2011	6515.075	2850.12	3664.95	2.2217	0.0617
2012	6909.99	3080.08	3829.91	2.6646	0.0322
2013	6672.55	2946.08	3926.467	2.5606	0.0375
2014	6778.18	3531.56	3246,033	2.5019	0.0409
2015	4596.255	3290.89	1305.362	0.8978	0.3991
2016	3994.695	4212.33	-217.635	-0.1447	0.8890
2013-2016 (Average excluding BUI)	5560.421	3495.217	2065.205	1.9986	0.0858
2007-2016(Average)	5690.135	2882.843	2807.292	2.6541	0.0327
Software Used: STATA 12					

Given the contribution of thermal plants to power generation a further four-year period from 2013 to 2016 is analysed to determine the significance of Bui and the new IPPs. Table 6.8 excludes Bui which started production in 2013 and all firms where output fall outside the 10 year period.

Tables 6.9 and 6.10 show that the differences in power generation and ownership structure of the power generated are not statistically significant from

2013 to 2016. In other words the reliance on hydro has been neutralised by the thermal sources.

Table 6.9

T-tests of Differences ESoS by Inputs/ Technology (Hydro and Thermal) from 2013- 2016

T-test					
	(1)	(2)	(3)	(4)	(5)
Year	Hydro	Thermal	Difference	t-value	p-value
2013	4883.36	2946.08	1937.28	1.1304	0.2914
2014	5127,12	3531.56	1595.50	1.1103	0.2991
2015	3789.17	3290.89	498.27	0.3936	0.7042
2016	3449.71	4212.33	-762.53	-0.608	0.5599
2013-2016(Average)	4312.36	3495.21	817.14	0.7313	0.4854
Software Used: STATA 12					

Table 6.9 includes Bui in power generation mix or sources. This reduces the mean for hydro as against increasing generation by thermal firms and from other thermal sources.

In keeping with the endowment theory (Burke 2010) and sustainability (Larsen et al. 2017) if thermal plants have increased their contribution to power generation, it has implications for sustainability issues in terms of fuel for power generation, its availability and reliability of supply. Again, it has implications on foreign exchange to procure the oil or gas if domestic supplies are not adequate. Furthermore it requires more infrastructures for pipelines to transport the gas, port facilities to take in the LNG as the floating pipeline facility, LNG storage facilities to store gas for energy security and proper management of the environment.

It also requires new skills in managing the grid facilities to accommodate the generation of power by synchronising the physical distribution system given the location of the power plants through their bulk supply points to avoid congestion which can lead to power failure (Röpke 2012).

Table 6.10

T-tests of Differences Average ESoS by Ownership Type (IPP and State-owned) from 2007 to 2016(Excluding Bui Project)

T-test					
	(1)	(2)	(3)	(4)	(5)
Year	**IPPs**	**State – Owned (SOEs)**	**Difference**	**t-value**	**p-value**
2007	**3471.55**	**2098.35**	**1372.89**	**1.0410**	**0.3325**
2008	**2575.07**	**2657.81**	**-82.73**	**-0.0531**	**0.9591**
2009	**2120.00**	**3783.23**	**-1663.23**	**-0.921**	**0.3877**
2010	**2756.78**	**3700.25**	**-943.47**	**-0.5341**	**0.6164**
2011	**3427.23**	**3854.41**	**-427.17**	**-0.2380**	**0.8187**
2012	**3209.00**	**4508.90**	**-1299.89**	**-0.7953**	**0.4526**
2013	**3538.85**	**4042.31**	**-503.60**	**-0.2838**	**0.8089**
2014	**2871.76**	**5358.046**	**-2486.27**	**-2.140**	**0.0696**
2015	**3320.73**	**3789.168**	**-468.43**	**-0.3682**	**0.7236**
2016	**4505.01**	**3891.126**	**1238.47**	**0.4957**	**0.6353**
2007-2016(Average)	**3179.57**	**3768.37**	**-588.80**	**-0.4773**	**0.6477**
Software Used: STATA 12					

However table 6.10 shows the analysis of the average ESoS by ownership which reports that the contribution by IPP was statistically significant in 2014 at the 10% level. The years, 2013, 2015 and 2016, the mean differences in power generated by state-owned plants and IPPs were not statistically significant at

1%, 5% and 10% levels. Table 6.11 shows that with inclusion of Bui, as an IPP, the differences in means are not significant. A further analysis was considered whereby the imports from CIPREL in La Cote d'Ivoire were excluded to assess the impact of ownership within the Ghanaian jurisdiction. The results obtained from Table 6.11 below also show that the differences in means are not statistically significant.

Table 6.11

T-tests of Differences Average ESoS by ownership (IPPs and State-owned) from 2013- 2016(including Bui Project)

T-test					
	(1)	(2)	(3)	(4)	(5)
Year	**IPPs**	**State – Owned (SOEs)**	**Difference**	**t-value**	**p-value**
2013	**3012.08**	**4042.454**	**-1030.372**	**-0.6238**	**0.5501**
2014	**2662.414**	**5358.046**	**-2695.632**	**-2.5776**	**0.0327**
2015	**3091.584**	**3789.168**	**-697.376**	**0.6091**	**0.5593**
2016	**4076.01**	**3891.126**	**184.88**	**0.1576**	**0.8787**
2013-2016(Average including Imports and Bui)	**3210.524**	**4270.198**	**-1059.674**	**-1.0713**	**0.3153**
2013 -2016 (Average excluding only Imports from CIPREL(Cote d'Ivoire)	**3716.735**	**4270.198**	**-553.463**	**-0.5744**	**0.5837**
Software Used: STATA 12					

6.6.0 REGULATORY AND POLICY IMPLICATIONS OF FINDINGS

Riding on the shoulders of Di Bella and Grigori (2017) and Prévost and Rivaud (2018) the following regulatory and policy measures are suggested for consideration in the immediate to short term.

The first is that, the current regulatory framework needs to be strengthened. This should result in better rules for the sector, reduce entry barriers, should ensure an efficient utilisation of available units and in the composition of investment between alternative technologies, while pushing overall investment upwards. There is a large room to improve regulation, transparency, and the accountability of the sector, all of which should also result in better expectations of the sector's solvency. Revising tariffs to reflect costs (including theft), and to allow for an efficient utilisation of electricity supply would prevent large industrial and commercial clients to move to off-grid self-generation. Dispatching rules should be reformed in order for generation costs to become the main driver behind the use of available generation units. Publishing all PPA contracts, auditing VRA and ECG accounts and publishing the audits, and implementing a competitive and transparent bidding process for new IPPs would serve this purpose. A revision of PPAs to reduce the wide dispersion of costs across similar technologies would help to contain expenses.

There must be an improved level of the law that enforces timely tariff recovery and also reduce theft and delinquency. This should greatly improve the investors' perceptions of solvency, essential to ensure adequate investment levels. Solvency prospects depend largely on the cleaning of the cumulated arrears and stronger penalisation of delinquency and theft. Penalties for non-payment should be reviewed and enforced. ECG's own governance should be improved so as to ensure that it plays its central role in ensuring adequate billing and collections. Regular inspections on clients and evaluations on the quality of service should be led by the regulatory body and result in an improvement in collection. Regularisation plans should be introduced, at least for clients with a large stock of arrears. This, in turn, would help to create a culture of payment for smaller clients. Being one of the largest ECG's customers, the government should regularly pay its electricity bill and centralise the payment of electricity bills for all central government institutions. The budget should make space for the cost of public lighting, which is currently above the municipalities' finances. Implementing these measures decisively will make government promises to further tackle theft more credible and should facilitate investment. They will also improve the cash recovery index which is calculated as the product of the billing rate times the collection rate (Arlet 2017).

It is widely acknowledged that reliable and low-cost electricity provision is critical for economic activity. Nonetheless, bad configurations of the electricity sector are relatively common in many low-income countries, and these can get them stuck in a bad equilibrium characterised by high electricity costs, electricity shortages, expensive self-generation, and large fiscal subsidies arising from unbalanced cross tariff subsidisation, fraud and non-payment. Countries that managed to transition to a better equilibria for their electricity sector, are characterised by better regulatory frameworks (including adequate tariff setting, the enforcement of penalties, and appropriate energy dispatching rules), lower generation costs, lower theft ratios and government subsidies, and investment levels that are large enough to guarantee an electricity supply that is commensurate with peak electricity demand.

If bad configuration of the electricity sector influences generation and therefore the electricity security of supply, the next chapter will examine the causal relationship between the electricity security of supply and firm-level endowments and regulatory measures over the research period from 2007 to 2016.

CHAPTER 7

MULTIVARIATE AND PANEL DATA ANALYSIS

7.1 INTRODUCTION

This chapter first reports the dependence of the electricity security of supply (ESoS) on the regulatory and firm-level risk variables in Ghana using the pooled OLS, the fixed effects and panel random effects regression models discussed in chapter 5. The chapter seeks to achieve three main objectives. The first is that, it empirically tests the hypotheses in chapter 4 to ascertain if the identified regulatory and firm –level variables significantly affect the ESoS in Ghana or not as discussed in the empirical literature. Secondly, it summarises the research findings in this chapter. The third is that, it tries to present the implications and recommendations of the research findings.

7.2 EMPIRICAL FINDINGS: PANEL DATA REGRESSION ANALYSIS

This section presents the initial panel data regression results for the full sample power generation sources. In order to test the hypotheses, we used several estimation methods. First, we applied pooled ordinary least squares (OLS), assuming that a common error structure applies to all generation firms. Yet, treating generation firms as homogeneous entities is most likely too strong a restriction. Furthermore, there is the need to reduce the potential that pooled OLS outcomes will be biased or inaccurate if time-invariant individual effects are observed. Another option would have been to estimate the firm specific effects as fixed parameters.

The purpose for including the fixed effects model in this analysis is that, it will remove any biased or unreliable pooled OLS estimator that can be attributed to time-invariant individual effects from the error term and the autocorrelation of the error term (Verbeek 2008). We therefore in principle assume that all (unobservable) factors that influence individual firm behaviour, but that are not captured by our regressors, can be summarised by a random error term.

Primarily, the random effects model will account for the potential that individual effects vary over time (Park 2011). Also, we are not so much interested in the value of the unobserved firm-specific effect, but rather in making inferences with respect to population characteristics. Therefore, the random effects (RE) model is estimated. We tested our final specification whether the pooled OLS, fixed effects (FE) or RE was to be preferred using both the Hausman specification test and the Breusch-Pagan Lagrangian multiplier (LM) test. The estimates pooled, fixed and random effects regression results based on the specific regulatory and firm-level risk management variables are reported in Appendix 5.3. The favoured estimation methods are reported in sections 7.3 to 7.10 to test hypotheses one to five.

Overall, five hypotheses are tested in this chapter as follows:

H_1: The size of a generating plant is positively related to the level of electricity security of supply in Ghana.

H_2: The level of electricity prices is not related to electricity security of supply in Ghana.

H_3: The quality of regulatory substance and governance is positively related to the level of electricity security of supply in Ghana.

H_4: The level of sustainability practices attained by a power generating firm is positively related to electricity security of supply in Ghana.

H_5: The ownership of the power generation plants is not related to the level of electricity security of supply in Ghana.

7.3.0 TEST OF PANEL REGRESSION ASSUMPTIONS

Following Erdogdu (2014), Battaglia and Gallo (2015) the panel data analysis is used as the most efficient tool because of the way the research data is structured. The panel data structure allows us to take into account the unobservable and constant heterogeneity, that is, the specific features of each power generating firm (management style and quality, market perception, business strategy, etc.).

There are several different linear models for panel data. The fundamental distinction is that between fixed effects and random effects models. The primary estimation method is generalised least squares (GLS) random effects (RE) technique. This is because the random effects technique transforms data to get rid of autocorrelation in errors. This technique is therefore robust to first-order autoregressive disturbances (if any) even within unbalanced-panels and cross-sectional correlation and/or heteroskedasticity across panels (Battaglia and Gallo 2015).

In the presence of unobserved power firm fixed effects, the panel fixed effects (FE) estimation is commonly suggested (Wooldridge 2002). However, such FE estimation is not suitable for our study for two main reasons. First, time-invariant variables cannot be estimated with FE regression, as it would be absorbed or wiped out in ‘within transformation’ or ‘time-demeaning’ process of the variables in FE. Thus, GLS RE is considered as an alternative to FE (Battaglia and Gallo 2015). The choice of the GLS RE model is also based on the results from the OLS diagnostic tests, which is summarised from Appendices 5.2 and 5.3. Table 7.1 below presents the summary of the diagnostic tests carried out in Appendices 5.2 and 5.3.

Table 7.1: Summary results of OLS and Panel Data Diagnostics

Diagnostics	Type of Test	Test Statistic			P-values		Implications
Normality	Swilk e	W			0.20079		Normally distributed
	Swilk r	W			0.20079		
Homoskedasticity	Breusch-Pagan (BP)/Cook-weisberg	χ^2 0.16			0.6886		Homoskedastic
Multicollinearity	Mean Variance Inflation Factor(VIF)	VIF			1.53		No multicollinearity
Autocorrelation	Breusch-Godfrey	Lag (1)	20.697		0.0000		Presence of autocorrelation
		Lag (6)	22.470		0.0004		
Model Specification	Linktest	_hat			0.003		No specification error
		_hatsq			0.127		
	Ovtest	F	0.94		0.4241		No specification error
Choice of Model	Breusch-Pagan	27.10			0.0000		FE/ RE and not Pooled OLS
	Hausman	3.46			0.6290		GLS Random Effects
Robust GMM Model Specification	Hansen J Test	**Sig.**	**χ^2(1)**	**J Test**	**Models 2 and 3 P-values**		The GMM Model is valid and is properly specified
		1%	6.635	0.0431	3	0.8355	
		5%	5.025	0.0427	2	0.8362	
		10%	2.706	0.8083	1	0.7762	
Source: STATA 12							

Table 7.1 shows that there is the possibility of autocorrelation in the data. This is followed by the results obtained from the Breusch–Pagan, Hausman and Hansen's J tests shown in Appendix 5.3.

7.4 PANEL RESULTS

The results of the various estimation methods used are presented in Appendix 5.3. The results report the pooled OLS, the fixed effects model and the random effects model, and the GMM estimator to the model to tests the robustness of the GLS random effects model results. They show the full sample regressions in which we include all the regressors. A positive co-efficient indicates an increase in electricity security of supply and a negative one indicates a reduction in electricity security of supply. In general the results from the GLS random effects model and the GMM are very similar.

In all, firm-level and all the regulatory variables, namely, size and sustainability appear to be statistically significant. Again following Beck et al (2013), the absolute values of the coefficients of the significant variables are as follows: plant size coefficient varies between 252.83 (FE) to 908.97 (GMM robust); sustainability coefficient varies between 102.76(FE) to 121.99(GMM hac-bartlett); ownership coefficient varies between 150.58 (RE) to 821.18(GMM Robust) as shown in Appendix 5.3.

A noteworthy first result from all the two tables is that we do not find much evidence of the significance of a firm-level variable –ownership and the other two regulatory variables, tariffs or financial efficiency and regulatory reforms.

The absolute values of their coefficients are as follows: tariffs or financial efficiency coefficient varies between 816.03 (GMM robust) to 1,110 (FE); and regulatory quality coefficient varies between 53.23 (pooled OLS) to 148.30 (RE).

Two results are especially worth pointing out. First, we find a consistent and significant direct influence of size and sustainability practices risk. The second is that the constant remains significant in all the estimation methods used. Regarding the estimation method, we employed two commonly used estimators that have been used before in the power market structure and electricity security of supply literature by Vagliasindi and Besant-Jones (2013); Erdogdu (2014); Hayland (2016): the fixed or random effects panel estimator and the GMM estimator. The choice to work with random-effects rather than with the fixed effects version is based on the Hausman test which rejects that the coefficients are significantly different.

Given our static panel data specification, a further robust test is undertaken by using the linear GMM estimator based on the panel GMM estimator formalised by Hansen (1982). The Hansen test, tests the null hypothesis that the model is valid and the J-statistic is asymptotically chi-squared with $K – L$ degrees of freedom, where K is the number of moment conditions, and L is the number of estimated parameters. Again the J statistic is not significant even at 1% significance level, so we conclude that our model is valid and not mis-specified (Hayashi 2000).

Table 7.2: Panel- Data Random Effects and GMM Regressions of Determinants of Electricity Security of Supply (ESoS) in Ghana

Model	(1)	(2)	(3)
Dependent Variable	ESoS	ESoS	ESoS
Estimation Technique	Random Effects (RE)	GMM (HAC-Bartlett)	GMM (HAC-Bartlett Newey West)
Power Generation Firm –level variables			
Size	645.196*	897.047***	904.383***
	(0.096)	(0.002)	(0.001)
Oship	-150.589	748.084	793.3
	(0.803)	(0.283)	(0.214)
Sability	113.867***	121.991**	121.517***
	(0.006)	(0.014)	(0.006)
Regulatory variables			
Reg	148.302	84.129	81.701
	(0.637)	(0.818)	(0.825)
Fineff	1038.909	801.706	855.198
	(0.421)	(0.254)	(0.340)
Constant	-15541**	-17232.37***	-17101.59***
	(0.017)	(0.002)	(0.003)
Hansen's J		0.8362	0.8355

Notes: The dependent variable is the Electricity Security of Supply (ESoS) which is the actual plant production in MWh discounted by the nameplate capacity. The firm-level control variables are: Size(Plant Size or Investment) is the natural log of plant size installed during production; Oship (Ownership) is dummy variable, taking the value of 1 if the generator is state-owned or 0 if it is an IPP owned and controlled by private investors irrespective of the VRA or state holding which is insignificant; Sability (Sustainability) which takes a scale of 1-120. 120 represents the highest and 10 the least score. Dependence on domestic input supply attracts 50, not dependent on the weather is 20, foreign exchange for the importation of input attracts 30; political stability of source of input supply 20. The regulatory-level control variables are: Reg(Regulatory Governance) which takes a scale of 1-6. 6 represents the highest and 1 the least score; and Fineffect (Actual Price per kWh/ USD) is the natural log of price in US dollars. Instrumentals for the equation include regulatory governance, price-cap or financial, size, sustainability, ownership, contract type and constant. HAC standard errors based on Bartlett kernel with 9 lags by the Newey –West method; HAC standard errors based on the Bartlett kernel with 88 lags. *P* values are in parenthesis; * Significant at the 10% level, ** Significant at the 5% level, * Significant at the 1% level. Coefficients are on top of parenthesis.**

Software Used: STATA 12.0.

The Breusch–Pagan, tests the null hypothesis that the individual (or time) specific variance components are zero. This was rejected to conclude that there is significant random effect in the panel data and that the random effects model is able to deal with heterogeneity better than the pooled OLS (Park 2011). The LM follows the chi-square distribution with one degree of freedom. The Breusch –Pagan (BP) chi-square statistic for model (1) is 27.10 (p-value is 0.0000) as shown in Table 7.1.

The Hausman test is further used to examine if the individual effects are significantly correlated with any of the regressors (Park 2011). The Hausman tests in this study for the model (1) follow the chi-square distribution of six degrees of freedom. The Hausman test statistic as presented in appendix 5.3, shows that for model (1) as shown in Table 7.2 is 3.46 (and Table H of the p-value is 0.629). These results suggest that we cannot reject the null hypothesis that the coefficients are the same. In other words, the results show that the individual effects are, in most cases, not significantly correlated with the explanatory variables, so that random effects model can be used to model generator level specificities.

7.5.0 FINDINGS AND DISCUSSIONS: PLANT SIZE AND SoES

This section examines the effect of plant size on electricity security of supply (ESoS) and its implications. Based on the results from Table 7.3 below, plant size was found to have a statistically significant and a positive relationship with the ESoS at the 1%, 5% and 10% levels using the GMM estimation methods.

Table 7.3: Firm –level risk and performance: Size results

Firm –level risk taking variable	Dependent Variable : ESoS		
	GLS Random - Effects(RM)	**GMM (HAC Bartlett)**	**GMM (HAC Newey-West)**
Size	645.196* (0.096)	897.047*** (0.002)	904.385*** (0.001)
*, **,*** indicates significance at the 10%, 5%, 1% levels. The p-values are in the parenthesis. **Source: STATA 12 and Tables 7.2**			

The relationship is statistically significant at the 10% level using the GLS random effects model. Thus, the evidence supports a positive relationship between electricity security of supply and the size of the generation plant in Ghana. We therefore have sufficient evidence to accept the hypothesis (H1), which states that, the size of the generator or power plant is positively related to the level of electricity security of supply in Ghana.

7.5.2 DISCUSSIONS

The study finds that that larger installed generation capacity which goes with higher capital investment in Ghana increased ESoS levels. The findings support the empirical studies by Vagliasindi and Besant-Jones (2013) who found a positive relationship between the size of installed capacity of 22 countries from 1989 to 2009 and electricity security of supply. Likewise Erdogdu (2014) found a positive relationship between plant capacity or reserve margin and security of supply using a sample of 55 countries including developing countries. Their findings suggest that increase investments into installed plant capacity promote generation growth in capacity short and resource abundant economies (Burke

2010). Increasing installed capacity is an investment decision with a long term horizon. This implies that political risk factors need to be taken into account and minimised in order to attract foreign investments in liquidity-constrained economies (Massie et al 2015). However their ability to generate power depends on input supply (IEA 2016).

As shown in Figure 4.1(the conceptual framework) in chapter 4, the positive relationship is in line with the expectation that given the increasing gas production in Ghana, the availability of physical generation capacity with assured bankability will significantly increase electricity security of supply. Bankability has extra cost for developing countries like Ghana where the configuration of the power sector has been poorly structured with legacy contracts which may not necessary reflect the medium to long term needs of the country. However, the method of power generation and the type of power asset needed for either thermal or hydro practically determine their relationship with electricity security of supply.

In the Ghanaian context, the need to increase assets for power generation or the installed capacity by generators means huge capital injection into a long term contractual relationship. Over the period of study demand has persistently increased and exceeded supply at peak periods. This creates the potential for market development to allocate power in a more efficient way. The second is the continued influence of government through the state ownership of plants or generators. This has created a hybrid market with the mature hydro projects like the Akosombo Dam, that have to a large degree fully depreciated their assets making marginal pricing difficult.

7.5.3 IMPLICATIONS FOR ENERGY LAW AND POLICY

The plants used for power generation are asset specific, are of high value and require longer period to recoup the investments. Given the state of liquidity constrain the state-owned utility firms find themselves in, the alternative for them to expand their asset base to generate power economically, therefore, falls on the private sector, possibly through public-private-partnerships (PPPs) or independent power projects (IPPs).

This will require that the legal framework and means to enforce measures that will attract them, need to be put in place. Empirical studies in the EU where there is no capacity shortness but has similar challenges to sustain investments had followed the following legal steps: administrative unbundling and legal unbundling (Barrett 2016). Again the empirical work by Eberhard et al(2016) shows that Ghana has in principle done some administrative and legal unbundling. The key component of allowing power producers to adjust prices to reflect changes in the cost of their inputs notably gas costs under fuel cost adjustments provisions in their tariffs is largely a political matter (Stickley 2010).

There is the need for the following critical actions to promote more capital injection into the financing of gas-to-power projects. First, because in most of the contracts examined the government guarantees the supply of the inputs (Eberhard et al 2016). In Ghana, given the contracts underlying the West African gas pipe and that of the model petroleum agreements, a critical look should be given to the possibility of sustaining the gas supply reliably from domestic sources. This demands that the government of Ghana reviews the

Gas Law which should capture tax incentives and provisions for extending contract development periods as well as purchase commitments, oil equivalent pricing, and payment guarantees. Provisions governing access by third parties to production -related facilities such as processing plants, mixed phased pipelines and storage facilities for gas liquids are needed to reduce development costs and provide market access (Stickley 2010).

In keeping with the findings of Phadke (2009) and Kashi (2015) that given the political risks investors ensure quick recovery of investments through the overstatement of plant investments and the quality of equipment, then the Ghanaian situation is a clear example of energy injustice(Heffron and Talus 2016a) as a result of poor configuration of the energy sector. Given the current level of energy debt around 6% of the GDP and with the government's attempt to defer the debt through the issuance of bonds does not change anything on the ground. The gas explored from the Jubilee and the new fields are being used solely for electricity generation but the electricity prices, sector debt and subsidy are rising. In other words the increase in supply of electricity is in line with the findings of Kashi (2015) that once the PPAs are negotiated that can allow for the accelerated recovery of overstated investment structure of the IPPs they will contribute to electricity supply.

Given the hybrid nature of the Ghanaian power market and the VRA being the offtaker, high transmission and distribution losses, tariffs below cost-recovery levels, and poor billing and collections have affected the financial standing of utilities in Ghana. This position is not different from the average distribution losses in Sub-Saharan Africa which is around 23 per cent compared with the commonly used norm of 10 per cent or less in developed countries (Eberhard et al 2016: 40). Moreover average collection rates are only 88.4 per cent compared with the best practice of 100 per cent. Combining the costs of distribution losses and uncollected revenue and expressing them as a percentage of utility turnover provides a measure of a utility's inefficiency. In Africa, this inefficiency is equivalent, on average to 50 per cent of turnover (Eberhard et al 2011: 134). Data analysed from the financial statement of ECG debtors, transmission, technical and operational losses provided by GRIDCO and VRA in 2017 shows that currently Ghana's case is around 35 per cent. The combined effect requires serious restructuring of both the cost structure of the producing thermal firms and the transmission and distribution of power to minimise the revenue risks facing the state-owned power producers.

The implication for policy is to revise the sequencing of reforming the energy sector at the meta, meso and micro levels. Given the existing commitments with the IPPs, the changes should be sequenced as follows. The initial stage is to create a credible power market by making sure all government departments settle their bills as due. ECG should be made to pursue an aggressive debt recovery program. The recovery index should be set and made public (Di Bella and Grigoli 2017). Public prosecution of defaulters and those who temper with meters should be enforced. The second should be targeted at investments into the grid system to avoid transmission and distribution losses caused by aging and poor quality infrastructure. A policy allocating a percentage of the revenue from power sales exclusive of transmission charges to support GRIDCO should be enforced. The third should involve public disclosure of the performance of both ECG and GRIDCO on how these measures have been implemented. The combined measures will improve and change the solvency risk the power sector is facing in the short term.

In the short to medium, there should be a systematic framework established for all IPPs. This is important to prevent the potential abuse of overestimating their investment costs. More importantly, the potential demand gap for investors should be auctioned or through competitive bidding once the approved standard is in place. The PURC should be strengthened with qualified staff who will understand the changing cost structure of these IPPs and will be able to respond to the need for price adjustments. The automatic price adjustment implementation should be reasonable and practical to reflect the economic realities.

At the meta level, the generation mix should be their primary focus to correct the existing poor configuration of the existing system. Financing of power generating plants using domestic financial system like the Ghana Stock exchange has never been used. Tax breaks and energy refinancing schemes should be introduced for individuals who invest in shares of energy projects yet to be completed like mini- hydro facilities will reduce the long term dependence of foreign capital for power generation. The law should allow for the callable options in such schemes, which allows the government to buy back some of the shares in these projects up to 35% to minimise potential political interference while promoting private sector participation. The future private public partnership law should have a specific section for the power sector.

7.6.0 FINDINGS AND DISCUSSIONS: FINANCIAL EFFECTS AND ESoS

This section examines the relationship between the prices of electricity and electricity security of supply and its implications. Table 7.4 below, presents the results across the estimation methods and show a positive relationship between electricity prices and electricity security of supply (ESoS).

The relationship between electricity prices and electricity security of supply is statistically insignificant but positive under all the estimation methods at the 1%, 5% and 10% levels.

Table 7.4: Firm –level risk: Electricity Pricing and ESoS results

Firm –level risk taking variable	**Dependent Variable ESoS**		
	GLS Random Effects(RM)	**GMM (HAC Bartlett)**	**GMM (HAC Newey-West)**
Electricity pricing	1038.909 (0.421)	881.706 (0.254)	855.198 (0.340)
*, **,*** indicates significance at the 10%, 5%, 1% levels. The p values are in the parenthesis. **Source: STATA 12 and Tables 7.2 and 7.3.**			

Table 7.4 therefore shows that, there is no sufficient evidence to reject the hypothesis (H2) that the level of electricity prices per kWh is not related to electricity security of supply in Ghana.

The sign of the coefficients (albeit not significant) is in line with recent empirical studies on electricity prices and electricity security of supply by Swadley and Yũcel (2011) in the USA, Nagayama(2009) in developing countries and Erdogdu (2011; 2014) in both developed and developed countries. Vagliasindi and Besant -Jones (2013) found that electricity supply correlates positively with average tariffs and similarly found the relationship not statistically significant.

7.6.1 DISCUSSIONS

This positive relationship supports the theory of supply which says that higher prices lead to an increase in supply as far as the price exceeds the marginal cost in a competitive market. In the long run it holds so far as price exceeds the average marginal cost and average cost of production. There are variations in the cost structures for hydro and thermal plans that are affected by their respective technology and age of the projects. Empirical and comparative studies by Eberhard et al (2016) show that the tariffs paid by firms and households in Ghana are among the highest in Sub-Saharan Africa. If that is so, then there exists some degree of normal profit for the IPPs, while the state-owned power producers are receiving less. Alternatively, this may suggest that there is an additional subsidisation by government due to political pressure (Vagliasindi and Besant-Jones 2013:65). Similarly they found that tariffs levels in Zambia and South Africa were low due to political pressure while Uganda, Kenya and Tanzania kept tariffs at a moderate level.

The subsidisation is coming from the high degree of losses as discussed in chapter 6 around 25 per cent which prevents the actual flow of revenue to actually oil the wheels of state-owned power producers because the PPA signed with the IPPs have to be complied with or enforced to ensure some level of security of supply.

On the other hand, a negative relationship implies that there is inherently 'missing money' which needs to be addressed by the government or the regulator. This is reflective of the slow level of capacity expansion given the existing mismatch between demand and supply which means that price effects appear to be temporal due to inflation, driven by the foreign exchange movement against the local currency. In addition are the effects of both counterparty and revenue risks that undermine cost –reflective production costs as a result of the timing of the cash flows either through the receipt of subsidies or from the direct recovery of tariffs in Ghana. This implies that making the value chain liquid is critical to restore a rational producer and price relationship where there is no abuse of excess rent seeking.

The insignificance of the relationship potentially arising from the inherent 'missing money' may also imply that there is a thin line between the expected positive, neutral or negative effect of prices on ESoS in Ghana. This situation reflects the existing the supply convexity in the Ghanaian power market. In keeping with Kaminski (2012) the Ghanaian power sector supply curve in the short run is characterised by high convextity making the curve close to being horizontal due to the rigidity of the existing infrastructure, the fuel supply risks taken up by governments in the IPP contracts whilst having growing and timely financing of fuel input and import challenges. These factors do practically restrict the sector's short term potential for additional generation and distribution of electricity. As a result, the supply curve becomes very inelastic. In otherwords in the short run because investors are discouraged as expected producer surpluses evaporate into thin air due to exchange rate fluctuations, political and regulatory risks make passthrough costs into pricing difficult and sticky. The high initial capital required for any power generation and distribution expansion creates lumpiness problem in generation (Rodilla and Batlle 2012). These factors described above also combine to affect the price and ESoS relationship in the medium to long term in Ghana.

7.6.2 IMPLICATIONS FOR ENERGY LAW AND POLICY

These findings have many implications and a policy requirement to produce more power at a lower cost. Therefore, the resource based value chain needs to be reviewed first from the gas or input side. Referring to Figure 4.1, the findings call for the establishment of aggregators for both demand and supply of gas in Ghana. These aggregators will in the medium to long term promote effective gas-to-power sales and where domestic production exceeds demand, promote its exports.

The second implication revolves around changes in the fiscal, regulatory and financial arrangement around the distribution sector where the role of independent distribution projects (IDPs) should be encouraged. This can be done through concessions which can integrate the benefits of auctions from power generation to distribution. Auriol and Picard (2013) provide insight into the relevance of concessions through build-operate –transfer (BOT) and build-operate-own-transfer (BOOT) concessions. From the economics and law perspective BOT and BOOT contracts are close substitutes where the concession holder gets the ownership of the infrastructure in addition to the tasks to build and operate it. In BOT contracts, the public authority retains ownership over the infrastructure while it contractually confers control and cash flow rights to the concession holder. From a legal viewpoint, BOOT offers more protection to the concession holder as it limits the government's legal public authority to unilaterally change a concession contract. However, in practice such unilateral actions are rather infrequent.

A concession grants a private firm the right to operate a defined infrastructure service and to receive revenues deriving from it. Concessions vary according to their risk allocations and incentives, investment and service responsibilities, and how tariffs are set. Usually, a concessionaire pays a fee to the concession-granting authority, and then incurs investment expenditures and collects payments directly from users over time. At the end of the concession period, there could be compensation for investments that have not been fully amortised. There could be provisions regarding early termination and non-compliance with the agreed terms.

Concessions differ from privatisation in three main respects. First, the physical assets remain owned by the state, even though the use of the assets and the operation of the enterprise are transferred to the concessionaire. Second, concession contracts are of limited duration, typically 15-30 years. Third, the government typically retains closer oversight of concessions.

Concessions are often viewed as a substitute for privatisation when it is not feasible for political or legal reasons. Concessions are generally followed by regulation but, under certain circumstances, substitute for regulation. There is empirical support for substantial efficiency gains from concessions, but the experience has been marred by substantial renegotiation which can dissipate the gains. Studies of the Latin American efficiency gains from concessions are summarised in Estache et al (2003). In electricity, they show that the rate of productivity change is 1 per cent per annum across 39 firms in a dozen countries.

Engel et al (2001) argue that to avoid costly renegotiations, the use of auction mechanism, where the BOT is granted to the candidate who bids the least present value of the concession revenue is most appropriate. With this type of allocation mechanism, the concession ends only when the concession holder has realised revenue it has bid for: the franchise term endogenously adjusts to possible shock realisation. However to be implemented, such a mechanism requires that the concession holder's revenue be observable and cannot be manipulated. This reinforces the argument for high regulatory skills and monitoring.

Again there are economic and political justifications for the use of BOT concessions in Ghana. In keeping with the findings of Auriol and Picard (2013) concession decisions are made by politicians in Ghana who have higher opportunity costs of time than concession holders. When governments are impatient due to political pressure for the security of electricity supply, rationality holds that they will favour BOT concessions. Democracy forces governments to discount the future more than their former entrenched dictators. Similarly BOT are particularly relevant in times of budgetary crisis as one finds in the energy sector in Ghana. It is clear that the issuance of energy bonds which will raise the level of Ghana's debt to GDP ratio to over 70% makes the opportunity costs of public funds rise sharply and unexpectedly, favouring BOT concessions over public management.

Finally, concessions are relevant where government and firms face the same uncertainty about their profitability at the time of the concession signature and where the project characteristics can be transferred at the end of the concession as in the case of COMPACT II concession in Ghana.

7.7.0 FINDINGS AND DISCUSSIONS: REGULATION AND ESoS

Hypothesis H3 is about the relationship between the level of regulatory quality (substance and governance) and electricity security of supply. The results in Table 7.5 show a positive relationship between ESoS and regulation.

Table 7.5: Firm –level risk: Regulation and ESoS results

Regulatory–level risk taking variable	**Dependent Variable ESoS**		
	GLS Random Effects(RM)	**GMM (HAC Bartlett)**	**GMM (HAC Newey-West)**
Reg	148.302 (0.637)	84.129 (0.818)	81.710 (0.825)
*, **,*** indicates significance at the 10%, 5%, 1% levels. The p values are in the parenthesis. Reg is regulatory quality. **Source: STATA 12 and Tables 7.2 and 7.3.**			

There is no sufficient evidence to accept the alternative hypothesis (H_3). In other words we do not reject the null hypothesis. The results are weak as none of the coefficients in all of the models estimated is statistically significant at the 1%, 5% and 10% levels. The results confirm the empirical evidence by Eberhard et al (2017) that there seems to be no correlation between the growth in IPPs and the quality of regulatory changes in many Sub-Saharan countries.

The results show that regulation of the power sector has some industry-wide challenges including system wide framework for pricing, grid investment cost allocation, downstream sector losses and operational independence to overcome in order to achieve the expected significant impact. This can be attributed to the current surface approach to the reforms. As a result of the poor sequencing of reforms, their impact do not reflect fully the ex-ante and ex-post power sector risk management challenges relating to the inception, take-off and mainstreaming phases of the power sector market reforms. The regulation of the power sector is key to implementing the framework for an efficient, well running utility whether public or privately owned with the following expectations or outcomes: operational autonomy; financial autonomy and clear reliable funding sources; accountability; customer orientation; market orientation; and transparency (World Bank 2017: 21) and therefore require a more careful attention across board.

7.7.1 DISCUSSIONS

The positive regulation coefficient is consistent with the expected view in energy law and policy literature that effective regulations lead to an efficient gas-to power sector development, economic growth and lower power prices (Swadley and Yũcel 2011). The results show that power generation firms identified as having high security of supply values could potentially have had higher levels of performance if regulations have been effective in Ghana with respect to the choice of equipment and their level of operational efficiency(Kashi 2015), e.g. Takoradi T3 plant.

At the country level, the overall economic conditions and legal framework are clearly relevant, as well as policies that encourage private investment into the power sector in general. Stable macroeconomic policies, investment protection, respect for contracts, capital repatriation, tax incentives, and further IPP investment opportunities will attract more capital at lower cost. Transparent, consistent, and fair regulatory oversight, with commitment to cost-reflective tariffs, provides more price and revenue certainty, boosting the credit worthiness of offtakers and thus requiring less risk mitigation.

7.7.2 IMPLICATIONS FOR ENERGY LAW AND POLICY

As discussed in chapter 6, section 6.10.1 findings support the argument that increased investment into Ghana's power sector needs explanation from other areas which may include poor deals against the country as in the case of recent renegotiation between the government of Ghana and the Ameri Group over the excess cost of the IPP project. This again reinforces the need to have a regulatory regime that has the understanding of power planning and the timely initiation of competitive tenders or auctions for new capacity. At the project level, debt and equity financing has to be appropriately structured and serviced through the revenue guaranteed in a robust PPA and backed with the required credit enhancement and security arrangements, including guarantees, insurance and other risk mitigation instruments.

The discussions in relation to concessions and the attraction of investments through auctioning mechanisms have severe constraints in developing countries like Ghana as their successes depend on the number of bidders (Auriol and Picard 2013) and in many instances one bidder (Kashi 2015). This weakens the strength of government's negotiation. It leads to the request for government guarantees to see a financial closure. Regulations with respect to guarantees, timing, value and processes should be in place to avoid frontloading debts in an attempt to improve the security of electricity supply.

Ghana must have a regulatory framework for long term contracting for power. The framework should define how power gaps will be auctioned whether by joint auction by a central entity before tending contracts to distributors as in the case of Brazil or the Ministry of Energy and the GRIDCO organise capacity contract auctions and payment by consumers as in the UK for example. The question of the autonomy allowed to generators in terms of investment should not be flexible as found in Chile but should be within the defined time as found in the UK and Brazil. Buyers and sellers should be regulated as found in many jurisdictions such as Brazil, Chile and in the UK (Roques and Finon 2017).

Critically contract structure should be based on capacity and energy terms as found in Brazil. Technology neutrality should include renewable energy sources technology. This is where the current regulation needs to be improved. The current regulation should provide an effective mechanism to support net metering policy as experienced in the USA to promote standalone investments into renewable energy (Saka et al 2017).

Regulation should aim strategically at avoiding the endowment trap in support of findings by Collier and Venables (2012) who explain that African countries have a high potential for hydrocarbons, hydroelectric power, and solar power. However lack of capital, skills, and governance capacity make the new green energy options very expensive in comparison to traditional sources. Hence, the development of new green technologies is constrained, and traditional options of energy still remain the major sources of power.

7.8.0 FINDINGS AND DISCUSSIONS: SUSTAINABILITY AND ESoS

Hypothesis H4 assesses the relationship between the sustainability practices of power generating firms and electricity security of supply. The results presented in Table 7.6 show that reliance on domestic inputs for power generation, less dependence on foreign exchange to procure inputs, use of renewable inputs, less reliance on imported power or inputs positively affected electricity security of supply in the study period. In other words, the results from Table 7.6 show that ESoS is positively and significantly affected by the sustainability practices of power generating firms in Ghana. The two estimation models, random effects and HAC Newey-west models, report that the relationship is statistically significant at the 1%, 5% and 10% levels.

Table 7.6: Firm – Level Sustainability Characteristics and ESoS results

Firm - level variable	Dependent Variable ESoS		
Sability	**GLS Random-Effects(RM)**	**GMM (HAC Bartlett)**	**GMM (HAC Newey-West)**
	113.867*** (0.006)	121.991** (0.014)	121.517*** (0.006)

*, **,*** indicates significance at the 10%, 5%, 1% levels. The p values are in the parenthesis. Sability is Sustainability.

Source: STATA 12 and Tables 7.2 and 7.3.

The GMM (HAC Bartlett) estimation model also reports a significant relationship at the 5% and 10% levels. The results provide sufficient evidence to accept the hypothesis that the level of sustainability qualities of a generating plant is positively related to electricity security of supply in Ghana.

7.8.1 DISCUSSIONS

The diversification of electricity sources has occurred in Ghana. However, due to energy security and environmental concerns, in the Ghanaian case, this new electricity generation mix is not necessarily a more renewable and cleaner mix. Since thermoelectricity has begun to occupy more space in the electricity mix and, in turn, hydroelectricity has lost share, various new socio-environmental aspects have become relevant. Previously, the effects of power generation on the environment were concentrated along dammed riverine systems in areas occupied by reservoirs, including the wild flora and fauna present in these areas, and the local population. Today, the rise of thermoelectricity brings concerns about negative externalities related to pollution such as particularte and greenhouse gases emissions. So, a better situation from the socioeconomic and environmental perspectives can be obtained by energy policies that optimise the combination of all energy sources available in a given society.

A positive coefficient on sustainability implies that an increased recognition that a low carbon source of power generation and alternative sources of energy from renewable are crucial to complement the current gas-to-power source of electricity generation. This implies that the reliance on gas is not the panacea to the sustainable electricity security of supply given foreign exchange constraints and other political risks from political instability in Nigeria and recently from Cote d'Ivoire could be minimised. Again dependence on foreign sources of power generation inputs can negatively and potentially affect the reliability of supply and thereby make the level of electricity security of supply in some cases uncertain. The finding of a positive relationship between sustainability and electricity security of supply is consistent with Burke (2010) who investigated the relationship between sustainability and power sector performance in 133 countries. Similarly Kileber and Parente (2015) examined the effects of the endowment trap and energy ladder theories on Brazilian electricity and concluded that renewable sources of energy are positively related to electricity security of supply, notably from wind and biomass which pose no foreign exchange and political risks on availability of inputs. In other words, they concluded that the availability of local inputs and the abundance of alternative sources are precursors to effective electricity security of supply. In Ghana, the Energy Commission has licensed many IPPs that are interested in solar energy and the VRA has also begun investments into solar energy to diversify its generation capabilities. Given the importance of sustainability variables on electricity security of supply, there is the need to deepen the laws, regulation and policies on low carbon energy sources in addition to the optimisation of the use of gas resources at the country's disposal.

7.8.2 IMPLICATIONS FOR ENERGY LAW AND POLICY

If the improvement in the generation of renewable sources power can lead to improvements in the level of electricity security of supply, then the regulatory authorities should promote the development of a low carbon electricity generation culture among the potential IPP investors in keeping with KYOTO and Paris 2015 (the climate change process).

The current law allows for renewable but feed in tariffs, pricing, and subsidisation processes have not been adequately defined as one finds in Denmark and in Scotland. Solar energy potential is huge in Ghana and if it is well harnessed, it can reduce dependence on fuel imports.

The difference between hydropower provision in Brazil and Ghana which led to increase cost of hydrogenation has been transmission distances (Kileber and

Parente 2015). In Ghana the dams are located relatively closer to areas where there is higher population concentration than in Brazil. Therefore, the development of the Volta basin and mini dams over Akobra and Pra rivers can also improve carbon power generation culture. There is an absence of policy linking water basin management and electricity security of supply in Ghana. Such water basin policy should focus on the reforestation of the basins to minimise the cost of de-silting of the rivers in the medium to long term. Farming and illegal mining along the rivers should be prevented and enforced, while settlements which promote deforestation and the silting of rivers should be controlled aggressively.

Strategically, the cost savings made from the gas which is a depleting resource should be invested in renewable energy to support the sustainability efforts. Again this can be founded on a credible power market structure which is solvent (Di Bella and Grigoli 2017).

7.9.0 FINDINGS AND DISCUSSIONS: OWNERSHIP AND ESoS

Hypothesis H5 examines the relationship between the ownership of power generation plants and electricity security of supply in Ghana. Table 7.8 below shows a negative and not statistically significant relationship between ownership and electricity security of supply at the 1%, 5% and 10% levels, when the random effects estimation model is used. However, the GMM (HAC Newey-West) and HAC Bartlett estimations show a positive but not statistically significant at the1%, 5% and 10% levels.

Table 7.7: Ownership: Ownership and ESoS results

Regulatory variable	Dependent Variable ESoS		
	GLS Random Effects(RM)	**GMM (HAC Bartlett)**	**GMM (HAC Newey-West)**
Oship	-150.589 (0.803)	748.084 (0.283)	793.30 (0.214)
*, **,*** indicates significance at the 10%, 5%, 1% levels. The p values are in the parenthesis. Oship is Ownership. **Source: STATA 12 and Tables 7.2 and 7.3.**			

The results suggest that there is no sufficient evidence to reject the hypothesis (H_5) that the state ownership of the generation plant is not related to electricity security of supply in Ghana. The results show that policy makers should critically review the dynamics of promoting privatisation and ensure in the transition the balance between the level of state-ownership and privatisation and how it impacts on electricity security of supply. In other words policy reforms promoting private participation in the energy sector in Ghana should in addition take into account the current concentration of government investments in the structure of power value chain and the age of these assets. Therefore, the government's capacity to finance the needed grid infrastructure to support the changing generation mix over the entire implementation cycle should be given the needed consideration.

7.9.1 DISCUSSIONS

The study shows that state-ownership and continued government direct participation in power activities contribute to the reduction in the level of electricity security of supply in Ghana. Theoretically, the findings support or reflect the Ajayi al (2017) model of ESoS that distinguishes between liberalisation, privatisation and deregulation. Empirically, the results support the findings of Ajayi et al (2017) who in their study of OECD countries' public ownership and vertically integrated energy firms found that they are associated with high efficiency loss and no statistically significant relationship is established for entry barriers. This result reiterates the issue of private ownership in the power sector and Eberhard et al (2011) argue that increased government participation in power production lead to reduction in the level of electricity security of supply due to their persuasion of political goals in developing countries.

The GMM results tell us to interpret the GE Random Effects result with caution and not to assume that privatisation is the alternative view and as the panacea in the Ghanaian case. Electricity privatisation serves to take the government out of the business of supplying energy. Instead, the role of the state becomes that of provision of an enabling environment in which others will provide the service. In a liberalised market, the state becomes a facilitator. It becomes responsible for setting the rules, and for establishing the framework controlling the structure of the industry, but it is not in the day to day running of the business. Electricity security of supply remains a responsibility of government, but rather than discharge that responsibility through ownership, the government instead creates enabling conditions for others to provide secure, diverse and sustainable supplies of energy (Dow 2008).

The effects of privatisation on the security of supply have been mixed depending on the time frame (i.e. short term or long term) within which the evaluation is being considered. Fundamental to the evaluation depends on the model adopted by the country in question. Erdogdu (2014) citing Sioshansi (2006) show that the basic structure of the power industry was organised and operated as state –owned enterprises under government control or as privately owned monopolies and regulated. Where governments nationalised and consolidated the electricity industries into state-owned, legal monopolies as found in many European countries such as the UK privatisation schemes have been carried out in various degrees (Polemis 2016).

Privatisation without competition implies that there is replacement of the state monopoly with a private monopoly. Privatisation alone does not change the natural monopoly element in the downstream energy sector. By itself, privatisation does not introduce competition. By itself, privatisation does not change the pricing structure of the industry. Private sector monopolies are profit oriented rather than service oriented. Any efficiency gains are incentivised by regulation, not by markets (Dow 2008).

The transfer of the ownership of the vertically integrated state-owned utilities into a more competitive and privatised schemes may decrease or leave unaffected the electricity performance (Polemis 2016). This is in line with studies and the finding by Pompei (2013), Fiorio and Florio (2013) with the argument that the possibly of privatisation would lead to lower output, at least in the short run. It can be explained from the empirical findings that there were severe problems revealed by underinvestment in the UK electricity sector. The explanation further lies in the fact that the electricity industry is charaterised by large sunk investment and significant externalities which are present in the distribution and transportation segments of the market. These features of the industry may provide governments with the possibility of behaving opportunistically, and thus private investors may be cautious about investing in capacity (Lee et al 2018).

The long run effect of privatisation can also be seen from the effects of liberalising the private monopolies but the regulated model as in Japan, the US , Germany and Hong Kong (Edorgdu 2014). The problem with this model is where regulators in unbundling the electricity value chain do not adequately identify and rectify the inherent investment incentivisation risks. Therefore, caution should be exercised in the process of implementing first, the administrative functional unbundling, followed by legal unbundling and finally ownership unbundling to protect the benefits inherent in vertical integration. Empirical studies by Barrett (2016), Hayland (2017), Lee et al (2018) show that in many jurisdictions where the issue of distinguishing between legal unbundling from ownership unbundling had not been scrutinised or well analysed before their implementation, the result has been that regardless of the profit motive, the dependability and repayment ability have been underestimated. For example, by unbundling the power generation sector, as in the case of vertical unbundling, the incentive of grid investment can decrease because there is no benefit from generation. Regarding grid quality, Nardi (2012) also showed that ownership unbundling causes the deterioration of the grid.

Barrett (2016) citing Jones (2010) and Jones and Sufrin (2011) show that the theory behind unbundling is that when applied to network-dependent markets (in conjunction with measures designed to facilitate third-party access to networks and increase network regulation) it will open up the market's profitable activities to competition. In theory, unbundling is expected to deliver benefits such as increased efficiency; innovation; market-driven investment; improved customer service and cost-reflective (and potentially reduced) prices; for the market as a whole. Thus, in the electricity sector, unbundling refers to the separation of the electricity network (transmission and distribution systems) from the more profitable activities of development and supply. On the other hand, the overarching process of opening electricity markets to competition (using this and other means) is referred to as electricity market liberalisation. To be successful, unbundling requires two equally important elements.

The first is market design accompanied by ex -ante regulation, or regulation to prevent/impede breaches of the law and anticompetitive behaviours ever occurring by putting an independent regulator in place as the first step to achieving successful market separation. The second is the enforcement of the rules and standards designed to give effect to the new market design and existing law by ex post enforcement of jurisdictional law (i.e. enforcement which reacts to conduct which is either taking place or has taken place) (Barrett 2016).

Barrett (2016) however show that liberalisation process in the EU has been carried out with the introduction of energy reform packages. These energy packages were expected to create market structures which would lead to cost-reflective consumer prices; greater market transparency; improvements in electricity efficiency and customer service; greater investment in infrastructure and the creation of a truly interconnected internal electricity market (Barrett 2016).

Liberalisation has been carried out partially or fully in the Scandinavian countries while in other countries monopolies in the value chain have been maintained as in the UK (Dow 2008). Newbery (2015) however argues that while liberalisation is at the heart of EU energy policy which aims to deliver security, sustainability and affordability, but of these three objectives politicians treat security of supply as over-riding. Given the need to instantly balance supply and demand in the electricity system, ensuring short-term security of supply is normally an obligation placed on system operators, while longer term capacity adequacy is often the subject of regulatory and political concern (Newbery 2015). Liberalisation is aimed at promoting competition while privatisation has been carried out to secure national fiscal revenues in some countries, regardless of the inefficiency (Dow 2008). Privatisation comes with some challenges.

The relationship between privatisation and liberalisation lies in the basic power market model initially introduced. In developing countries like Ghana, Imam et al (2018) suggest that in order to attract investments many reformers advocated total privatisation of state-owned utilities to complement other forms of private sector participation. The withdrawal of the state from the sector would not only attract the needed extra private sector investments, but would also reduce the burden of subsidies on the government from financial overruns of state-owned utilities. Therefore, privatisation has the potential to reduce political interference or bureaucratic rigidities in the operations and management of utilities since control rights over these factors would no longer be under the direct control of politicians or civil servants. This suggests that privatisation can improve the performance of the sector through changing the incentive structure. The theory of privatisation can in part be traced to the theoretical work of Boycko et al (1996). The owners of privatised utilities are the residual claimants of revenue generated by the services their utility firms provide. These private investors are therefore incentivised to reduce inefficiencies, particularly those related to corruption (Olson 2002) or corruption through institutional failures (Deakins et al 2017). This differs from when services were provided by state-owned utilities without clear residual claimants, and thus no incentives to reduce inefficiencies especially those related to corruption (Imam et al 2018). Liberalisation therefore represents the means to reform both state-owned and private monopolies but regulated power sector market structure globally.

The importance of distinguishing privatisation from liberalisation is that privatisation is not a prerequisite for liberalisation (Larsen 2013: 5) although privatisation does require liberalisation (at the minimum in the form of a new entrant) (Dow 2008). Dow (2008) suggests that liberalisation is an entirely separate concept from privatisation, not as a single concept but is instead a scale. Larsen (2013) argues further that in theory, competition and incentive regulation can also be employed in the case of state owned companies. Dow (2008) operationalises the distinction between privatisation and liberalisation by arguing from the legal and control perspectives that there is the need for the government to know who the participants are in the downstream energy sector because of its strategic importance and also the imperfect competition which the liberalisation model creates in practice. Dow (2008) further shows that such control is easily established by means of a licensing system established under primary legislation. The other reason for new legislation underpinning liberalisation is that it typically requires little legislation to run a state monopoly. The law may simply grant the monopoly to a state company – and then everything else is done by agreement between the state company and the Minister. There is no real need for a law until liberalisation is introduced, and a law is needed to establish the parameters of the market as the Minister cannot directly influence a private company (Dow 2008).

Therefore, distinguishing between privatisation and liberalisation helps us to understand the recent findings by Polemis (2016) who examined the structural reforms in the EU electricity sector from 1975 to 2011. Their findings were in alignment with similar studies (Pompei 2013; Fiorio and Florio 2013), in which it is argued that privatisation of state-owned monopolies would possibly lead to lower output, at least in the short run. These findings which are also consistent with experiences gained in the UK and in some US states have shown that market prices have often led to under-investment and an energy mix which does not guarantee the security of supply, decarbonisation and price affordability. In the UK, the 15 electricity utilities that emerged from the reforms of the 1990s re-integrated and consolidated to just six utilities after 5 years. This has led to the perception that the utilities tacitly collude to charge consumers higher prices (Lewis 2014). Similarly, the idea that the market would discipline competing firms and thereby benefit consumers was tested by the California power crisis in 2001. Byrne and Mun (2003) reported that various participants in the California electricity market succeeded in gaming the system to maximise short-term profits by creating artificial scarcity through their bidding strategies.

Therefore, instead of lowering prices, the day-ahead, hour-ahead, and real-electricity markets led to increases in prices. Imam et al (2018) and Lee et al. (2018) stress that privatisation and liberalisation should be implemented with a well - designed regulatory structure and framework to prevent potential and market failures.

In the UK, Lee et al (2018) show that there was the case for suspending the licensing of new gas power plants, as the gas-power generation increased rapidly. In Korea, on the other hand, Lee et al (2018) show that electricity capacity markets after the reform failed to reflect the opportunity costs of the generation facilities, so the base-load share dropped.

Lee et al (2018) further introduce an additional dimension or element in assessing the issue of electricity security of supply, based on the ability of the country to import power or not due to the existence of an isolated power supply which can also exist in developing countries due to the absence of infrastructure and not necessarily from geographical constraints. The relevance of increased supply from imports also depends on the sufficiency of power generation by import sources and the existence of a synchronised grid system with neighbouring countries' grid system.

Larsen (2013) therefore suggest that given the abstruseness of how effective the reforms have been, it is not surprising that individual consumers are skeptical towards the sector as many feel that electricity is a necessity. Therefore, its provision should not be jeopardized in reform experiments where they do not know whether the outcome will be positive or negative for them (Larsen 2012). The main focus should rather be on the fact that electricity is a fundamental infrastructure need for economic transformation which should be made available at affordable prices and sustainably (Burke and Best 2018).

Ghana has not privatised its electricity sector yet but has liberalised it to allow IPPs to support the generation of power. In keeping with Polemis (2016) liberalisation is recommended to help increase the security of supply. The question is: why does public ownership of plants lead to a mixed outcome in the quality level of electricity security of supply in Ghana? The explanation to the random effects (RE) result can be explained in alignment with the findings by Kileber and Parente (2015) in Brazil who show that the security of supply is reduced when the efficiency of the hydro sector is not as high as that of the thermal and the renewable sector dominate the generation mix coupled with plants being largely owned by the state.

In Ghana, plants are mainly hydro along with low capacity thermal plants that are also owned by the state. The explanantion to the GMM results is that the short term effects of the less opportunistic behaviour through government ownership and investments have had a positive effect on electricity security of supply in Ghana given the lessons empirically shown by Imam et al (2018) and Lee et al (2018).

7.9.2 IMPLICATIONS FOR ENERGY LAW AND POLICY

The lesson from Brazil should guide policy makers in Ghana to refocus their attention on the renewable segment which can be portable, adaptable and can easily attract Ghanaians into participating in the ownership of their green plants. If these studies are showing that the best is to allow the market to be liberalised and privatisation may undermine the security of supply due to the overpricing of investments, foreign exchange and other related issues, then the existing publicly owned power firms should left intact but their governance should be strengthened.

The quality of the management teams appointed by the government to manage these energy firms' affairs notably the mainstreaming aspects therefore matters. Board appointments should be based on competence and the regulatory fitness tests have to be revised and redefined with emphasis on energy management skills. Similar findings were made by Edomah et al (2017) in the Nigerian case. These skills are needed for the sustained management of water basins, plant security, price negotiation etc.

Recent attempts by the government of Ghana to privatise the assets of the state generators have been met with strong political resistance because experiences in other sectors such as the telecom sector. The other argument is the fear of job losses by the existing staff but the overall challenge is the quality of institutional framework to support the smooth process of offloading state assets to private ownership on the Ghana Stock Exchange to release funds for the settlement of debt hanging on the state power producers.

The primary policy is to have a balanced state and private participation in the electricity sector through market liberalisation (Barrett 2016) with strong and effective regulation that incentivises investments, affordability, sustainability and security of supply (Newbery 2015). Competition should be encouraged in the generation with the strategic lenses of ensuring that renewable energy sources are given the needed support. Again the participation of IPPs should be streamlined through proper concrete planning from the Energy Ministry.

The planning should run concurrently with implementing measures that will make the sector solvent. The lessons from the Chinese which Ghanaians can learn from, is the education of the populace about the fact that electricity is not just any commodity for a politician to provide but it is the foundational resource needed by every country in its modernisation and development framework.

It should be understood that energy issues are financial matters which the Chinese understood before they put in place their reforms. That has not been the case in Ghana. This should be integrated in the development of Ghana's stock market which the Chinese did by setting up multiple investment bodies in the power markets (Ngan 2010).

These investment bodies should ensure that there is liquidity in the power market and that proper accountability is enforced to promote confidence and sustained growth of the market. These institutions can have budgetary backing as a double anchor which can support long term capital funding of projects. Tax rebates and exemption should be given to investors in the power sector whose transactions satisfy the regulatory reporting standards.

These institutions should have been in place alongside the deregulation and the liberalisation policies pursued by the governments. Again private producers should be given the right to sell power and collect their tariff through private distributors by providing to segmented markets.

A summary of all the hypotheses and results of the models are presented in Table 7.8 below.

Table 7.8: SUMMARY OF ALL HYPOTHESES AND MODEL RESULTS

Variables	Hypothesis	Form of Hypothesis stated	Expected sign of the relationship	Empirical Results/effect on security of supply	Conclusion
H1: Size	The size of a generating plant is positively related to the level of ESoS in Ghana.	An Alternative Hypothesis	Positive (+)	Positive(+) and statistically significant	Do not reject the Hypothesis or do not accept the Null hypothesis.
H2: Financial Efficiency	The level of electricity prices is not related to ESoS in Ghana.	A Null Hypothesis	Positive (+) or Negative (-)	Positive (+) and not statistically significant	Do not reject the null Hypothesis
H3: Regulation	The quality of regulatory substance and governance is positively related to the level of electricity security of supply in Ghana.	An Alternative Hypothesis	Positive(+)	Positive(+) and not statistically significant	Do not accept the Hypothesis or do not reject null hypothesis
H4: Sustainability	The level of sustainability practices attained by a power generating plant is positively related to electricity security of supply in Ghana.	An Alternative Hypothesis	Positive (+)	Positive(+) and statistically significant	Do not reject the Hypothesis or do not accept null hypothesis
H5: Ownership	The ownership of the power generation plants is not related to the level of electricity security of supply in Ghana.	A Null Hypothesis	Positive (+) or Negative(-)	Negative(-) and not statistically significant	Do not reject the null Hypothesis

Source: Constructed from the quantitative hypotheses formulation guidance from Creswell (2014), the Summary of the Hypotheses inTable 4.6 and the Panel Results in Table 7.2.

7.10.0 BLINDER-OAXACA DECOMPOSITION

One of the main conclusions in Chapter 6 was that the state-owned firms in Ghana on average had a higher level of ESoS than the IPP generators. However, the differences in their factor endowments and how their interaction with each other given their contribution or the security of supply levels cannot be discerned from the preferred GLS random-effects model and the GMM results discussed in sections 7.1 to 7.9. To answer these challenging issues, the Blinder-Oaxaca decomposition is used, and the findings are discussed below.

Oaxaca first estimates two group-specific regression models, and then performs the decomposition. Tables 7.9 and 7.10 further report the interaction effects of electricity security of supply and their characteristics using the independent variables decomposed by their ownership either as a state-owned or an IPP.

The decomposition output reports the mean predictions by IPPs and state-owned generators and their differences in Tables 7.9 and 7.10 below. The decomposition results in Table 7.9 suggest that the mean of the SOEs (the electricity security of supply measure) is 3802.74 for state-owned and for 3169.17 for IPP generators, yielding a generation or supply gap of 633.56. In the second panel of the decomposition, the output, the generation gap is divided into three.

Table 7.9 Blinder-Oaxaca Decomposition of ESoS by ownership (ipp)

Blinder-Oaxaca Decomposition Number of observations =90 1: ipp =0 2: ipp = 1						
ESoS	**Coef.**	**Std. Err.**	**Z**	**p>I z I**	**[95% conf. Interval]**	
Differential						
Prediction _1	**3802.742**	**358.904**	**10.60**	**0.000**	**3099.302**	**4506.181**
Prediction_2	**3169.176**	**307.085**	**10.32**	**0.000**	**2567.30**	**3771.052**
Difference	**633.565**	**472.349**	**1.34**	**0.180**	**-292.221**	**1599.353**
Decomposition						
Endowments	**-314.040**	**567.45**	**-0.55**	**0.580**	**-1426.222**	**198.141**
Coefficients	**33.596**	**477.240**	**-0.07**	**0.944**	**-901.777**	**968.970**
Interaction	**914.009**	**601.558**	**1.52**	**0.129**	**-265.081**	**2093.10**

Software used: STATA 12.0

The first part reflects the mean decrease of 314.04 in the ESoSs of IPP generators if they had the same characteristics or predictor levels as the state-owned. The decrease of 314.04 indicates the endowment (technology, brands, strategies, and global presence) effect.

The second term quantifies the change in IPPs' ESoS score when applying state -owned firms' coefficients to IPPs characteristics which will lead to an increase of 33.59 in the ESoS score which is very small in effect. The third part is the interaction term that measures the simultaneous effect of differences in endowment and coefficients which is 914.01.The overall effect is the measured ESoS gap of 633.56 between state-owned and IPP generators. Therefore, the state-owned firms' coefficient of 3,802.74 is largely explained by their endowments and coefficients.

Table 7.10 Blinder-Oaxaca Decomposition of ESoS by Ownership Type (Ipp): Two-fold Decomposition Results

Blinder-Oaxaca Decomposition
Number of observations =90
Oaxaca, esos reg fineff size sability oship, by (ipp) pooled
1: ipp =0
2: ipp= 1

ESoS	Coef.	Robust Std. Err.	Z	p>I z I	[95% conf. Interval]	
Differential						
Prediction _1	**3802.742**	**351.962**	**10.80**	**0.000**	**3112.908**	**4492.575**
Prediction_2	**3169.176**	**289.985**	**10.93**	**0.000**	**2600.816**	**3737.557**
Difference	**633.565**	**456.036**	**1.39**	**0.165**	**-260.249**	**1527.38**
Decomposition						
Explained	**524.719**	**513.085**	**0.306**	**0.306**	**-480.909**	**1530.348**
Unexplained	**108.846**	**527.208**	**0.836**	**0.836**	**-924.463**	**1142.156**

Software used: STATA12.0

The results in Table 7.10 show the relative contribution of the state-owned and IPPs to ESoS by doing a two-fold decomposition showing the explained and the unexplained decomposition.

The explained decomposition refers to endowment factors specific to the type of ownership. The unexplained relates to policy. The results show that 82% of the ESoS gap is due to differences in endowments. The difference of 18% is due to government energy policy effects.

Table 7.11: Blinder-Oaxaca Decomposition of ESoS by Input Type (Intype)

Two-fold Decomposition Results

Blinder-Oaxaca Decomposition
Number of observations =90
Oaxaca, esos reg fineff size sability oship, by (input type) pooled
1: intype =0
2: intype= 1

ESoS	Coef.	Robust Std. Err.	Z	p>I z I	[95% conf. Interval]	
Differential						
Prediction _1	5691.885	287.345	19.81	0.000	5128.698	6255.672
Prediction_2	2882.487	241.042	11.96	0.000	2410.412	3355.282
Difference	2809.038	375.058	7.49	0.165	2073.936	3544.14
Decomposition						
Explained	1792.111	538.468	3.33	0.001	736.731	2847.49
Unexplained	1016.927	644.667	1.58	0.115	-246.597	2280.452

Software used: STATA12.0

A further decomposition based on input type, that is either hydro or thermal which showed significant differences between them from 2008 to 2014 (see Table 6.8) presents further information which should guide policy makers. Tables 7.11 above and 7.12 is shown below, with the two component decomposition (Table 7.11) indicating the significance of endowment (64%) and policy (36%). The three component decomposition on Table 7.12 also shows that if thermal firms were to have inputs with similar characteristics as hydro, their output would have been up by 2,361.98. Again if the input coefficients of hydro plant are deployed by thermal firms output would have been higher by 1,677.59. The interaction between their endowments and coefficients reduce output by 1,230. 54.

Table 7.12: Blinder-Oaxaca Decomposition of ESoS by Input Type (Intype)

Three-fold Decomposition Results

Blinder-Oaxaca Decomposition **Number of observations =90** **1: intype =0** **2: intype = 1**						
ESoS	**Coef.**	**Std. Err.**	**Z**	**p>I z I**	**[95% conf. Interval]**	
Differential						
Prediction _1	**5691.885**	**358.904**	**18.89**	**0.000**	**5100.587**	**6283.183**
Prediction_2	**2882.847**	**307.085**	**11.62**	**0.000**	**2396.673**	**3369.022**
Difference	**2809.038**	**472.349**	**7.19**	**0.000**	**2043.532**	**3574.544**
Decomposition						
Endowments	**2361.98**	**692.754**	**3.41**	**0.001**	**1004.206**	**3719.753**
Coefficients	**1677.598**	**587.031**	**2.86**	**0.004**	**527.037**	**2828.158**
Interaction	**-1230.54**	**886.388**	**-1.39**	**0.165**	**-2967.829**	**506.75**

Software used: STATA12.0

7.11 CRITICAL REVIEW OF BLINDER-OAXACA DECOMPOSITION RESULTS

Since our analysis is based on a ten-year period from 2007 to 2016, our results should be viewed as applying to the short run and medium term. If and when state –owned and IPPs ESoS scores converge as regards their structure and behaviour (endowments), the differences as observed by us would gradually disappear.

Convergence may mean two possibilities. Either the state-owned firms reduce their endowment and coefficients effects while that of the IPPs remain or increase or the IPPs increase their endowment and coefficient effects faster to eliminate the difference. It should be noted that if for example the endowments become equal, the differences will become zero, and the interaction effect will also become zero. The appropriate option given the results obtained from Tables 7.9 and 7.10 is that, the IPP generators will have to improve their endowments in order to enhance their security of electricity supply levels.

However, to the extent that the main difference between the state-owned generators and their IPP counterparts is that the state –owned firms are largely hydro plants that were established years ago and may have been considerably depreciated. Again the hydro is based on domestic input which is least affected either by foreign exchange, take or pay contracts in relation to the West African gas pipeline , the maintenance period on the Jubilee field for domestic gas supply or Ghana Gas Company’s operations.

This does not mean that climatic or hydrological risks have not been taken into account. The IPPs are mainly integrated in multinational energy firms like Karadeniz Energy Group (Karpowership) and General Electric (GE), with profit objectives whereas the state-owned have other political objectives. Our results would not be long-lasting if the sector is not made solvent. Again the assumption has been that groups are homogenous and therefore ignores variations in an individual generator’s approach to improve its endowment resources. For example, the state-owned firms had a mixture of hydro and thermal plants, while the IPPs are only thermal plants.

If one ignores the effect of emissions, then, the endowment differences may not be long-lasting, with the growing gas production domestically, it is imperative for the managers of local and state-owned generators to refocus their attention on the primary characteristics of the IPPs which sustain their global operations and their shareholder interests. These include their contractual relationships which always require robust revenue from their power generators plus additional guarantees from the government. Adaptation to current global risk management practice, staff development, efficient maintenance and retooling are among qualities that have to be taken into account.

If one considers emissions and other sustainability factors, then the endowment effects will be long lasting and requires that policy makers should rather promote investments into hydro plants, reengineer the use water flow through water retention and multi-damming. The contributions from other renewable energy sources have to be promoted to complement such drive. The focus should be on biomass from sugarcane, palm kennel nuts that are wasted as a major potential source of energy that are sustainable in Ghana. These inputs do not require foreign exchange challenges and they create employment and growth in both urban and rural settings.

Again a local power generator should invest in their accounting and risk management systems, and seek some local equity injection by showing to the financial market that their financial statements presented and disclosed are of the highest quality. This will reduce in the short to medium term their overreliance on concessionary loans from development financing agencies to support the serious expansion, replacement of equipment, and protection of the various water basins in Ghana.

Again the state-own generators should take a long –term view of the sector and invest in technologies that will complement their sustainability capabilities. The VRA's balance sheet should be strengthened by ring-fencing its export revenues and also ensure that equal recognition is given to their revenue from power generation.

7.12 CHAPTER SUMMARY

The regression analysis supports the importance of plant capacity investments levels and sustainability characteristics in significantly influencing the electricity security of supply in Ghana. The results are fairly robust using the contribution of the various contributors to electricity generation as a proxy for electricity security of supply in a developing country like Ghana. The results are also robust to the alternative estimations as the overall conclusions do not change regardless of the model estimation.

The Blinder –Oaxaca conclusions do provide insight into the importance of state –owned firms to Ghana's security of electricity supply relative to IPPs. It reaffirms the importance of the relationship between factor endowment and electricity security of supply in Ghana. Ghana still depends on renewable energy generation which makes economic sense as it reflects the resource base of the country, its cost effectiveness and a solid foundation for future leapfrogging to sustainability or decarbonisation of the country's power sector.

Although regulation, financial efficiency and ownership were not found to be significant the continued problems of the sector's solvency is a matter of concern which can be intertwined with the regulatory measures, role of government in planning, execution of state policies, privatisation or concessions and its negotiation ability in power contracts with investors. The Ghanaian policy makers appear to have ignored the effects of poor configuration of energy sector reforms on the long term sustainability of the sector and on the economy at large.

Legal rearrangements should cover the management of the natural resource endowment that lead to power generation diversity from the gas sector to the use of biomass. In keeping with the assertions made by Collier and Venables (2012) the energy law should be framed along the lines of the resources at the country's disposal.

Secondly the legal framework should have a component which deals with the financing of the projects and the various modes of financing including the role of government. The law should incorporate the requirement to measure the degree of power for the country's security of supply and monetise it from legal and operational angles. This will create room to negotiate effectively with prospective IPPs. Negotiation for power is not the same as negotiating with a prospective investor exploring for natural gas which can highly be speculative. In the power markets of developing countries like Ghana the main problems are the awareness gap and policies that will recycle the investments in the power sector for its sustainability.

Regulation (substance and governance) can effectively impact on power market reforms if the regulatory framework is rearranged in an integrated manner such that financial sustainability of the power market is placed at the centre of its design. The financial aspect will not only deal with financial operational standards and accounting, but also their disclosures and reporting to attract investors and consumers who are key stakeholders. If consumers value a product, it forms the basis for a reliable, secure and a viable market. Regulatory control through output or price setting will have little effect if the consumer stakeholder interests are not considered in a developing country like Ghana. The regulation should have recognised consumer groups who should have a voice in reporting on the quality of service and the true of cost of service to them. These outcomes should be matched with targeted pricing and output in any properly regulated market. The initial result would be to move the power sector from the short term cost need approach to recovery and then to full cost recovery (Kojima et al 2014).

This will pave the way for adequate investments into transmission and distribution in particular which may require concessional financing because private participation is unlikely. This reduces the cost of providing power across the network Röpke (2012). The short and long term effect will be the reduction in government subsidies. Subsidy reformation should be done through cost reduction as well as increasing revenues. The issue of long –term least cost power planning which includes power mix optimization, investment optimisation, commercialisation of power supply, and incentive regulation promoting cost reduction such as consumer price index minus efficiency savings regulations have been discussed earlier.

These measures will succeed if short term measures are firmly put in place and working. The short term measures include revenue collection for power purchased from producers, eliminate avoidable costs created by inefficiencies associated with transmission and distribution losses, under billing or under collection of bills and undue delay in the payment of bills by government ministries.

Discovering gas as a domestic resource is one thing and using it for power to avoid energy injustice to future generation is another thing. The generation capacity building approach by most countries which liberalise to attract investment use some form of a build operate and transfer (BOT) scheme. There are numerous variants on the scheme from BOTs to public-private partnerships (PPPs) (Sader 2000:13).

The devil from the Ghanaian experience is in the detail as to how the prices have been set or controlled; how long the period is; the identity of the offtaker (buyer) and the method by which the sales have taken place. The current methods have allocated the risks between the projects and the buyers. As the buyer, VRA has no credit rating (commonly the case with state owned electricity supply companies) in developing countries like Ghana, there is a need for a government guarantee.

The strategy has to think about how the government will respond to requests for guarantees and contractual requests to assume various risks and the response has been energy sector levies, issuance of energy bonds which again will have a meaningful effect if the credibility of the entire power system is established and the critical liquidation cycle sanitised and backed by law.

The next chapter will critically examine the sequencing of the power sector development that can potentially ensure a future state of capacity surplus in Ghana.

CHAPTER 8

ACHIEVING FULL ELECTRIFICATION: THE LEGAL, REGULATORY, FINANCIAL AND FISCAL REARRANGEMENTS

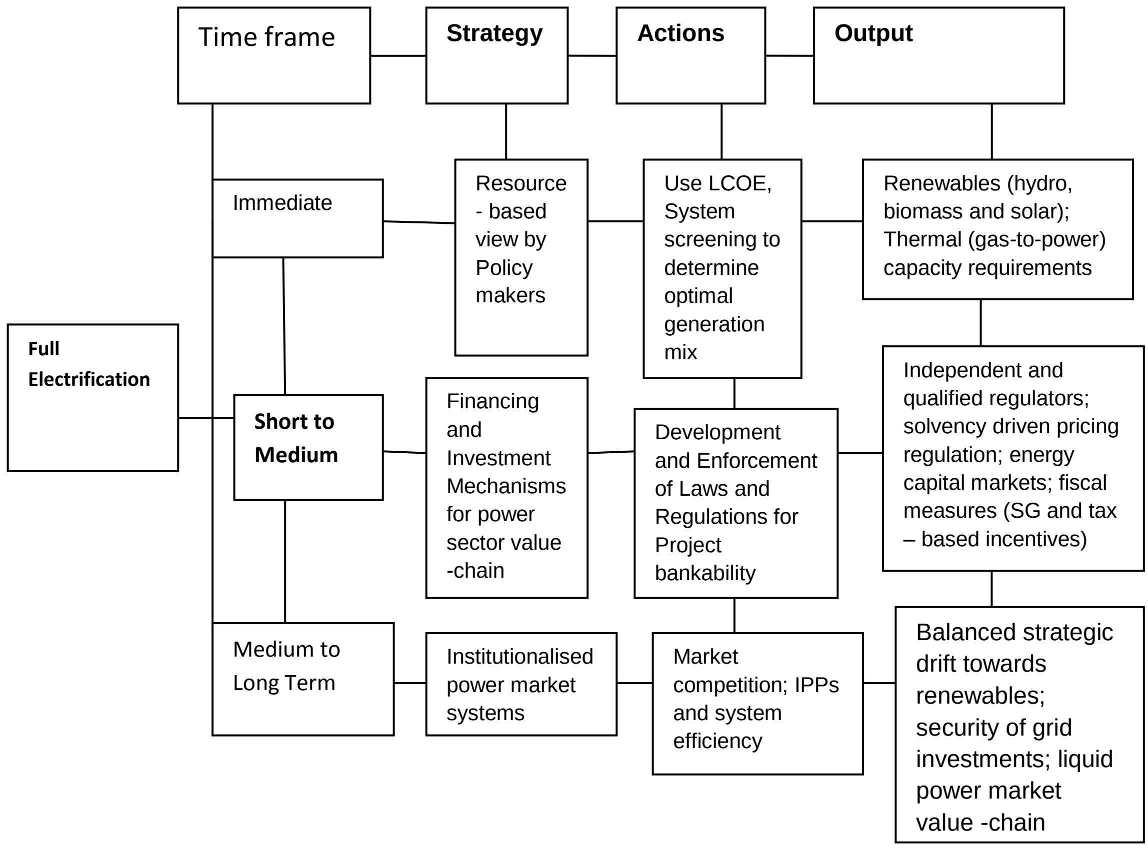
8.1 INTRODUCTION

This chapter examines the normative measures that will support Ghana to resolve its capacity shortness given the resource opportunities that it has. It recognises the existing poorly reconfigured electricity sector as discussed in Chapters 6 and 7 and aims to achieve the following five objectives. The first objective is to critically examine the framework for sequencing the reforms needed to eliminate capacity shortness in Ghana. The second objective is to discuss the challenges of managing to reconfigure the appropriate power generation mix.The third objective is to discuss the critical determinant, the project financing challenges and how they can be mitigated. The fourth objective is to discuss the role of government and the capital market in helping to resolve the problem. The fifth objective is to critically examine the interrelationships amongst the legal, regulatory, financial and fiscal measures that need to be rearranged in the Ghanaian context.

8.2 .0 THE KEY PRINCIPLES OF SEQUENCING POWER MARKET REFORMS TO ACHIEVE FULL ELECTRIFICATION

The proposed framework as shown in Figure 8.1 offers some qualitative guidelines on how financial, fiscal, legal and regulatory rearrangements impact on the predominant components and context of electricity security of supply (ESoS) that include: the security of access to reliable, affordable and modern electricity services; the security of electricity generation input supply development and co-operation, and reliability of power sector regulatory (political) process.

Figure 8.1: Strategic Sequencing of Sustainable and the Full Electrification Process in Ghana.



Source: Author and adapting or Integrating branches and trajectories from the new institutional economics (NIE) to the World Bank by Prévost and Rivaud (2018: 374)

The above strategic sequencing of a sustainable and full electrification is founded on the role envisaged by the new institutional economics and how it applies to the Ghanaian power sector. Figure 8.1 provides an insight into how the sequencing of a full electrification process is translated into strategy, actions and how to achieve the expected outcomes in Ghana with its abundant resource endowment. Apart from that, these qualitative policy analyses are important complements to the quantitative approaches carried out in chapters 6 and 7. It also addresses the inter linkages that exist between the different actor regimes and institutional endowments.

There are risks in developing specific power market types and the hierarchy of markets that arise from the demands they place on risk management and information requirements. The management of these risks requires the provision of certain benchmarks and principles of sequencing and co-ordination of domestic power market reforms. In keeping with Zaman and Brudermann(2018); Nepal and Jamasb (2015), Gratwick and Eberhard(2008) nine sequential milestones or elements for the completion of a country's power market reforms are: corporatisation and commercialisation, electricity laws, a regulatory authority, independent power producers, functional disintegration, privatisation of distribution, and generation, and wholesale and retail competition. The competitive electricity markets they argue do increase the security of supply and lower electricity tariffs by introducing market competition, system efficiency and increased power generation by the private sector.

Figure 8.1 therefore illustrates several of the key principles of sequencing power market reforms in Ghana. The first is that the success of these measures within the Ghanaian context and in many developing countries exhibiting similar macro and micro economic, incomes, political and resource endowment characteristics depends on the interdependencies in the policies, the pace and timing of the measures. More importantly, these measures should take into account political considerations that could strengthen the ownership of reforms.

The second is that reforms that require long lead times for technical preparations and capacity building should start early such as defining and formulating the sustainability of short to long term generation mix. This should take into account the Neo Institutional Economics position that there should be a balance amongst institutions, social capital, governance and development.

The third is that market development policies should be sequenced to reflect hierarchy and the complementarities of markets and related institutional structures. Policies should therefore be comprehensive (should include both renewable and thermal). Technically and operationally linked measures such as the legal framework, contract information design and disclosures should be linked together, and linkages among markets or value –chain should be taken into account. The strategy should capture inclusive green growth and ecosystem services.

Furthermore, power market development requires a careful sequencing of measures to mitigate risks in parallel with reforms to develop markets. These measures should be accompanied by the proper governance structure to contain risks introduced by new markets and instruments.

Finally and to consolidate the process requires policy makers to put in place good governance structures in the power sector value chain that will promote operational and institutional arrangements for policy transparency and data disclosure, internal controls, risk management systems and institutional capacity building to manage emerging risks.These governance -driven structures are the most critical of power market reforms in resource-rich but capacity short economies like Ghana.

The next sections therefore will critically examine in detail the strategy, actions and outcomes of the strategic sequencing of power reform to achieve a sustainable and full electrification in Ghana. The strategic themes are: the strategic or appropriate choice of power generation mix; the development of financing and management of power investment mechanisms and risks; the development of enforceable laws and regulations for power project bankability; and the financial and fiscal rearrangements for the generation capacity enhancements.

8.3 THE STRATEGIC CHOICE OF POWER GENERATION MIX

An important issue identified in Chapters 1, 2, 4, 6 and 7 is that Ghana remains as a developing country and therefore there is the need to critically evaluate the power generation mix because of the strong relationships that exist empirically amongst effective energy demand (the security of supply) (Blum and Legey 2012) who equated demand to the security of supply, income levels and economic development in Ghana (Atems and Hotaling 2018; Best and Burke 2018).

8.3.1 Theoretical and Empirical Literature

The Ghanaian situation can be posited from a strand of literature which follows the feedback, growth, conservation, and neutrality hypotheses. Omri (2014), citing Squalli (2007) explains that the feedback hypothesis states that there is a bi-directional causal relationship between energy consumption and economic growth. This implies that energy consumption and economic growth are interrelated and may very well serve as complements to each other. The growth hypothesis suggests that there is a unidirectional causal relationship running from energy consumption to economic growth. This implies that energy consumption plays an important role in economic growth both directly and indirectly in the production process as a complement to labour and capital. The conservation hypothesis postulates a unidirectional causality running from economic growth to energy consumption, implying that energy conservation policies do not adversely impact the economic growth. Finally, the neutrality hypothesis suggests that no causality between energy consumption and economic growth. This hypothesis considers energy consumption to be a small component of the overall output and thus have little or no impact on real GDP. It implies that neither conservative nor expansive policies in relation to energy consumption have any effect on economic growth. Narayan (2016) using a panel data of 135 countries concludes that empirical findings strongly support the neutrality hypothesis. In Ghana, it appears that the feedback and growth hypotheses can be observed (see figure 6.9). Implicit in these hypotheses is the strand of literature which looks at the relationship between income levels and electricity consumption.

Another strand of literature, the energy ladder (Narayan 2016), argues that the movement from hydro to more complex sources of energy to a degree is largely determined by income levels. However in Ghana, the increased use of thermal energy cannot be explained fully by using the energy ladder hypothesis. This means that in the Ghanaian case, there is the need to balance endowment and income inelasticity of demand. The analysis needs to take into account the distribution of incomes in Ghana, the growth sectors and their need for power in terms of intensity and the overall levels of affordability in deploying the new forms of energy sources. This is because income elasticity is relative to the societal income levels.

8.3.2 Implications for Eliminating Capacity Shortness: Actions and Outcomes

Having a balancing act has serious implications on the choice of power generation in the short, medium to long term. In the short term, given the structure of power production, the use of domestic gas needs to be harnessed to optimise its use. In addition opportunities for renewable source of power generation, notably hydro has to be looked at strategically and urgently. More dams can be constructed over many rivers in Ghana like the Pra and Ankobra. Ghana has an estimated additional hydropower potential of 2,000 MW, of which 1,200 MW is expected to be produced from proven large hydro sources, with the rest coming from small and medium –scale hydro sources. Approximately 70 feasible small (less than 1 MW) and medium (1-100 MW) hydro sites, with a total potential of 800 MW have recently been identified (Gyamfi et al 2015). Electricity from solar also has huge opportunities.

A recent study of by Sakah et al (2017) shows that Ghana has the capacity to develop its solar energy potential, considering the fact that many parts of the country receive 5-8 h of sunshine per day at $1Kw/m^2$.

Primary legislation providing a clear and well-designed legal framework for renewable energy is a fundamental signal of a government's commitment to harnessing its renewable resources. Importantly, it provides legally binding authorisation to develop the sector, and often provides guidance on how such development will be undertaken and the steps the government will take to support it.

This above analysis throws the challenge as to how these resources can be harnessed in line with the needed resource based view approach to being able to eliminate the capacity gap at the least and most efficient way as against the current ad hoc approach pursued by past Ghanaian governments. The legal framework can be part of a broader energy or power sector law or a stand-alone measure, but it must be enshrined in the vision for renewable energy and allow public institutions and private actors to understand their roles.

The World Bank (2016) through its regulatory indicators for sustainable energy (RISE), a global scorecard for policy makers suggests that a critical factor in designing a framework for encouraging investments into energy generation should show whether the private sector can legally own renewable energy generation capacity. Private ownership refers to any arrangement where a private operator retains revenue from power sales, such as build-own-operate or build-own-operate-transfer arrangements. It does not refer to private participation limited to project operation such as engineering, procurement and construction, or management contracts. Ideally, the private sector’s right to own and operate plants should be stated explicitly in the primary legislation, communicating to private developers their expected role in the sector, minimising regulatory risk, and ultimately reducing financing costs. But other instruments demonstrating equivalent de facto legal approval, such as regulations or permits designed specifically for private projects, also can provide potential investors with sufficient certainty to proceed.

The second issue is the proper management of the gas reserves as an input in the generation mix. The second domestic resource has been the development of Ghana’s gas resources. Government involvement in the development of natural gas includes the roles of resource owner emanating from its sovereignty, project participant, regulator and tax collector (Model Petroleum Agreement of Ghana 2000). The use of natural gas as a domestic source of energy is primarily influenced by the fiscal regime contained in the national energy policy. Options for the creation of a legal framework range from statutory monopolisation by state-owned corporations to deregulation. The Ghanaian gas sector can be described as emerging and therefore, the natural monopoly characteristics of access to facilities for processing and transportation mean that some form of governmental oversight is necessary particularly as a capacity short economy. The availability of gas for power generation from the gas fields will depend on the regulation of the gas produced. Regulation should therefore be made to influence the licensing for exploration of the gas, sale of the gas, use of regasification plants (in the case of gas importing countries) and pipelines.

With a policy that specifically addresses the development of natural gas for domestic use, the Government of Ghana (GoG) provides the incentives for natural gas use in the power sector by making provisions for extending contract development periods as well as purchase commitments, oil equivalent pricing, and payment guarantees. Other provisions governing access by third parties to production-related facilities such as processing plants, mixed phased pipelines and storage facilities for gas liquids in order to reduce development costs and provide market access are already in place despite the existence of state monopolies with the expectation of future expansion in gas production. The current primary roles of GNPC and BOST are that the generators do receive the gas and is of the right quantities and quality.

Policy towards cross-border gas trade from Nigeria tends to be sensitive to the security of supply. The gas is currently imported to supplement domestic supply. Exporting nations have generally determined that they have sufficient reserves to meet domestic requirements as well as to supply export markets (Stickley 2010) and contrasts the experiences of resource rich capacity short economies.

In an attempt to manage the growing gas reserves, the government regulates entry into the gas industry by ensuring that owners and operators of pipelines and LNG terminals have adequate operation qualifications and financial resources. This type of regulation also allows the government to facilitate the coordination of investments within the gas industry as well as related sectors such as power generation, and avoid creating redundant capacity and 'stranded assets'. Permits or Certificates of Public Convenience and Necessity as a standard requirement are only issued by a regulatory authority following a review of the pipeline route, market requirements, engineering design and environmental impact. The license may be exclusive or nonexclusive depending upon the level of competition for the right to serve a market. Competitive bidding may be desirable (Stickley 2006: 112-128). Restriction of entry has been used to create statutory monopolies by awarding exclusive franchises and concessions, or by restricting entry to state owned enterprises. In Ghana there are the state monopolies of GNPC controlling supply and BOST controlling the pipelines.

To ensure the security of supply the regulator should pursue an economic regulation that sets the rate of return that was allowable on investment. Tariffs are designed primarily upon whether the return on the pipeline owner's equity is subject to performance risk, such as annual throughput. Regulatory intervention attempts to promote economic efficiency by applying the cost of service model which sets tariffs such that total revenue is equal to total average cost. The current monopolistic structure requires the use of cost of service model. Further development or expansion of the sector in future should allow for the value of service tariff which will be based upon charging what the market will bear. This approach is best suited to a commercial environment where the parties have equal bargaining power or where there are competing alternative fuels. The level of the tariff is settled by arm's length negotiation between the users and the pipeline owner. If the pipeline supplying the natural gas has a monopoly position in the market, the tariff may not achieve an outcome that is economically efficient.

Gas sector reforms have been implemented in various forms depending on the specific circumstances in each country under consideration. Studies show that financial success in the gas industry is based on economies of scale (Stickley 2010). The key legal requirement is administrative and legal unbundling in the gas sector and not ownership unbundling (Barrett 2016). That means the Ghana Gas Company has to be separated from the control of GNPC and strengthened legally and financially to be the Gas Aggregator for the demand and supply for gas in Ghana.

8.4.0 THE DEVELOPMENT OF FINANCING AND MANAGEMENT OF POWER SECTOR INVESTMENT MECHANISMS AND RISKS

The next issue is the need to have or adopt a more informed approach to the integration of private investment into the electricity generation capacity in Ghana.

8.4.1: Theoretical and Empirical Literature

Yescombe (2014) distinguishes project finance from the financing of projects because projects can be financed in many different ways. Traditionally, development financing institutions have been the main sources of financing energy projects. However with competition for financing from other sectors, private sector investment is critical to achieving this. Eberhard et al (2017) define IPPs as power projects that are, in the main, privately developed, constructed, operated and owned; have a significant proportion of private finance; and have a long-term power purchase agreements with a utility or another off-taker. Along with Chinese-funded projects, Independent Power Projects (IPPs) represent the fastest growing sources of power investment in Sub-Saharan Africa including Ghana. These private financed projects are based on project financing techniques.

Project financing is a special approach which should be used to develop the Ghanaian power sector. Project financing is different from commercial financing which Ghanaian banks are largely exposed to. Project finance is the creation of commercial structures and financial packages for major development schemes or infrastructure projects by sponsors with their contractors and other project parties, to provide manufacturing or infrastructure facilities which deliver goods and services and generate operational cash flows. In creating those structures, experienced project sponsors and their advisors will anticipate the needs and requirements of investors and lenders, thereby creating 'bankable' deal structures and commercial packages.

A bankable deal is a project transaction which has a sound contractual structure, clear aims and rationale, reliable and credit worthy project parties, robust cash flow and a risk profile which is seen as acceptable by investors and lenders (Smith 2010). Project financing is centred on the principle of bankability. This means that risk is allocated to the party best fit to take the risk identified in the implementation of these projects. It is useful especially in developing countries to unlock the value of their natural resources and build the infrastructure they need to move forward (Finnerty 2013). Project financing can provide a cost-effective means of raising funds to support projects that are capable of standing on its own as a separate economic entity as expected by sponsors (Finnerty 2013).

The theory of corporate finance is relevant to understanding further project finance role in development financing and how it should be structured and arranged. In emerging countries such as Ghana characterised by market imperfections in the form of financing constraints has prevented the government from financing a positive –NPV energy project on its own.

Numerous reasons can be offered for the need to recognise these risks. The legal framework to protect these investments are enshrined in the constitution, the Lenders and Borrowers Act, 2008, the Companies Code1963 and as Amended (2016), Ghana Investment Promotion Act, 2013, Act 865, the Energy Sector Levies Act, 2015 Act 899 as Amended (2017), the Land Registry Act, 1962, Act 122 and investors have to take into account the laws and regulations in the Ghanaian environment. The current Lenders and Borrowers Act 2008, Act 773 is to be replaced by a Lenders and Borrowers Act with a Bill submitted to parliament under Lenders and Borrowers Bill 2017. The purported new act gives lenders the right to disposed of borrowers' assets with lesser constraints. It requires that the enforcement of security is subject to minimum 30 days waiting period, following the expiry of which the security trustee can take possession of the charged asset and dispose of it without the need for court enforcement proceedings.

An additional requirement for payment of stamp duty and registration of interest in fixed and floating assets are required under the Lands Title Registration Law 1986(in the case of land situated in a registration district) and under the land Registry Act 1962(in the case of other land). For example, Article 181(5) of Ghana's Constitution, 1992, provides that any international business or economic transaction to which the state is a party requires parliamentary approval before it can become effective. In the case of the Attorney General vs Balkan Energy Co.LLC (a project company supplying power generated by a power barge to the government under a PPA), supreme court found that the power purchasing agreement constituted an international business transaction for which parliamentary approval was required but had not been obtained. As a result of the decision in the Balkan case, developers and investors are required to obtain either a parliamentary approval for any transaction deemed international which the government of Ghana is a player or creates a potential financial liability, or certification by the Attorney General in respect of the particular transaction. The post structuring of the transaction, to confirm that the substance of the transaction is not international and the transaction is an ordinary commercial transaction, rather than a major transaction that could fall within Article 181(5) of the constitution.

These investment laws are not comprehensive to capture the challenges posed by energy transactions. These laws are premised on the assumption that investments are readily available to flow through these simple processes of company registration and the perfection of assets. They are inadequate in the energy risk management and legal space because legal instruments and frameworks including the standardisation of contracts, tiered levels of state guarantees in terms of time and size, transparency and disclosure requirements have to be negotiated by prospective investors.

There are political, economic and financial risks to contend with in bankable energy projects. Dupont et al (2015) point to three strands of literature in dealing with political risks in energy sector investments. The first strand is the practitioner-oriented literature on investment law. Political risk, in this strand, encompasses a relatively loose array of both specific government measures harming an investor's rights and various other types of hazards that have a political component. The second is the extensive literature on expropriation and foreign direct investments (FDIs) due to resource nationalism and low quality of institutions as explanatory variables. The third is the literature on states' reactions to economic difficulties, captured by the notion of 'politics in hard times' (Dupont et al 2015). They cite Gourevitch (1986), for instance, who identifies a range of broad policy options available to governments to respond to severe crises, including nationalisation and protectionism. Both options are likely to have an impact on foreign investors. This literature includes a range of domestic and international factors explaining the choice among the various policy options.

They crystallise these three strands in the literature into three main types of political risk, or three main sets of conditions in which political risk may materialise:(i) poor governance, such as a lack of respect of the rule of law, lack of transparency and of individual rights; (ii) severe economic conditions; and (iii) economic nationalism, including (but not restricted to) resource nationalism. These three sets of conditions rarely, if ever, exist in pure, isolated form. They argue that these sets of conditions rather occur in combinations of varying degrees of intensity.

Political risks as threats to the profitability of a project are derived from some sort of governmental action or inaction rather than from changes in economic conditions in the market place (Moran 1999). While Moran (1999) contribute towards the general framework to political risks such as the breach of an investment agreement as one which often occurs and generally explained under 'The Obsolescing Bargaining Model(OBM)' it is reconceptualised as a Political Bargaining Model (PBM)(Eden et al. 2004). Moran (1999), had argued that upon initial investment in a foreign country, multinationals have a good bargaining position compared to the host government. This is explained by the fact that once the sector –specific investments are made in the host country, these resources can be held hostage by an opportunistic host country. The longer the investor is in the host country, the more likely it is that the government's perception of the benefit-cost ratio offered by the investor falls, particularly if the investment turns out to be much more profitable than either the investor or host country anticipated and there are larger profit remittances to the affiliate's parent firm.

Eden et al (2004) further argued that technological spillovers and economic development encourage the emergence of local competitors, so that the host country becomes less resource dependent on the specific – project investor. In other words, over time as there are more likely to be local firms that could replace the existing investments, assuming that all the resources and capabilities to create a product exist in the host country. If the host government's perception of the benefit –costs ratio turns negative, the obsolescing bargain model hypothesised that the host country would demand more commitments from the investors, causing the original bargain to obsolesce (Eden et al 2004). It is further argued that one of the reasons for this is that a host government will not want the earnings earned from projects in its country to compensate possible losses of the multinational elsewhere (Moran 1999). Eden et al (2004) therefore reconceptualised the Obsolescing Bargaining Model (OBM) as a Political Bargaining Model (PBM) and emphasised that investors must bargain for favourable public policies as they also contribute to host country economic growth and have the effect of creating more resources for both the company and the country as they see OBM as a special case (Eden et al 2004).

Lamech and Saeed (2003), Massie et al (2015) however provide the specific nature of the political risks, that international investors in power sectors in developing countries experience. They identified adequacy of cash flows in the energy sector for ensuring a reasonable prospect of recovering costs and making investment a success as the first criteria followed by payment discipline and enforcement as the second in determining the success of project investments. Their work also pointed to governments' ability to adhere to the stability clauses, commitment to and enforcement of power contract agreements as being crucial to power projects viability.

Another source of political risks would be expropriation risks (Sader 2000). This is the risks that the host government will nationalise the assets of a multinational firm without paying fair compensation.

Political risk in the host country is an important factor that influences the probability that a loan will be serviced as scheduled. In general, Massie et al (2015) reconfigure political risks into traditional political risk, regulatory risk, and quasi-commercial risk. The traditional political risk category addresses risks related to expropriation, to the convertibility and transferability of currency, and to political violence. The regulatory risk category covers risks arising from the implementation of unanticipated regulatory changes, such as changes in taxation or foreign investment laws. This can affect the financial equilibrium of the operator (Guasch et al 2006). The quasi-commercial risk category encompasses the risks that arise if a project contends with state-owned suppliers or customers whose abilities or willingness to fulfil their contractual obligations towards the project may become questionable. This definition shows that political risk comprises a broad range of different risks. Some of these risks, such as restrictions on transferability, are easy to identify ex post, whereas others, such as changes in the tax law that may lead to creeping expropriation, are not. Moreover, risks such as expropriation or regulatory changes can be closely related to the corporate sector and even to individual firms. Other risks (e.g., corruption) apply to the entire society but can negatively impact an individual firm's performance.

We expect a project finance structure to help parties address political risk by rendering a government intervention less likely or by limiting the damage that such an intervention can cause to a project.

8.4.2: Implications for Eliminating Capacity Shortness: Actions and Outcomes

Given the Ghanaian legal framework for any investment activity, the issue of government being required to make commitments, which may be matched by, commitments from the home countries of the syndicated parties or investor, transforms the deal into an international agreement. In that case, *pacta sunt servanda* is applicable, likewise *rebus sic stantibus* (Botchway 2010). Botchway (2010) further suggests that project contracts have a judicial system that dominates its governance. The emerging pluralistic phenomena appear to show that the governance would inevitably be the domestic system supported by international treaties and norms as may be evident in Bilateral Investment Treaties (BITs) and International Investment Treaties (IITs).

This implies that Ghana's investment law should ensure that the following arbitral award principles are taken into account. They are the principles of legality; the principle of the public administration's discretionary power; and the principle of legal certainty and legitimate expectations. Within the public administration's discretionary power are related principles such as: the principle of proportionality; the principle of equality before the law as in the case of Aguaytia Energy LLC v Republic of Peru in 2008; the principle of the public administration's good faith; and the principle of legal certainty and legitimate expectations.

These legal requirements are important because two additional mechanisms can be used by investors to manage political risks (Kolo 1997). They include resort to international arbitration under the auspices of an international institution such as ICSID (International Center for the Settlement of International Disputes) which will deter the host government once they have signed on to the project agreement. Host governments cannot refuse to participate in the proceedings, should it arise.

The second is the critical participation of development banks in a loan syndicate should also help mitigate political risk. Development banks provide a political umbrella because they frequently interact with the different bodies of a government. If an adverse government intervention jeopardizes the success of a project, then a development bank can use the leverage stemming from its special status and from its repeated interactions with the government. In this case, the government will be aware of the negative effect that an intervention will have on the loan (partially) granted by the development bank and, thus, on the government's reputation at the development bank. Ultimately, the threat of reputational damage might deter government intervention.

The use of ‘multinational spread’ is similar to the suggestions by Eden et al (2004) except that the emphasis is on the inclusion of preferred lender status of financial institutions such as the World Bank. The risk even still exist here if the host country does not recognise that preferred lenders support is a scarce resource that needs to be managed and may arise during severe foreign exchange crisis as the prioritization of settlement may arise(Lazarus 2001).

Because of the separate incorporation of the project, government intervention that causes a project to fail becomes highly visible for the financial market participants. This visibility increases the political costs of government intervention. Additionally, highly leveraged projects tend to have little cash and pre-completion guarantees provide challenges such that the temptation for the government to expropriate the project is reduced (Finnerty 2013).

Finally, some contractual arrangements completely avoid government interventions that may affect a project. For instance, convertibility and transfer risks disappear if off-shore accounts are used (Massie et al 2015). Overall, political risks assessment and valuation remain a highly subjective issue.

8.5.0 DEVELOPMENT OF ENFORCEABLE LAWS AND REGULATIONS FOR PROJECT BANKABILITY

The pecking order theory and the associated trade-off theory when applied to power projects challenge policy makers to institutionalise structures that will serve as controlling and monitoring systems. Such structures are necessary to contain the risks and externalities that go with the power projects. These structures, either legal or institutional arise due to the asymmetric information that exists between the policy makers of a country and potential investors. If the electricity security of supply is related to affordability, then the use of legal and regulatory systems and frameworks to ensure affordability of power generated while meeting the needs of investors need to be analysed.

8.5.1. Theoretical and Empirical Literature

Starting with the theory of capital structure financing and applying it to power projects, Yescombe (2014) shows that they are highly levered due to the way project financing is engineered to allow for lending against the cash flows generated by the project alone, depending on a detailed evaluation of projects, construction, operating revenue risks and their allocation. The type of debt, its structure, against equity and contribution of sponsors and the expected return on their investments are influenced by several factors amongst which political and regulatory risks occupy the centre stage.

Guasch and Spiller (2002) cited in Guasch et al (2006:153)had estimated the premium on the cost of capital as a result of regulatory uncertainty-as distinct from country risk-in Latin American countries to be between 2 and 6 percentages points. The impact of that increase can be quite significant. They argued that, an increase in the cost of capital from 15 per cent to 20 per cent for a $100 million dollar project with a 25-year life would require additional payments to investors of about $5 million per year (Guasch et al 2006) Increases in the cost of capital then translate into higher required tariffs; lower annual fees, canons, or transfer fees; or higher required subsidies, if applicable.

Alternatively, the overall level of tariffs would have to be about 25 per cent higher for the first five years of the concession to realise a fixed net present value for the company (Guasch et al 2006).

Kashi (2015) extends the work of Phadke (2009) to provide deeper insights into the relationship between risk in developing countries and the cost of capital used in energy project financing. They argue that political risk is a major justification for increasing the target rate of return to equity in the agreement beyond a certain limit. These rates are stated in the contracts and can be compared with guaranteed returns for private investment in all other sectors in the economy.

Kashi (2015) further argue that high guaranteed rates of return on equity make such contracts an easy target for those who would like to accuse the government of corruption, of being too generous, or of being unable to negotiate efficient deals. The usual victim in such cases is the IPP. In other words, increasing the risk premium into the target rate of return in the IPP contract above a certain threshold can backfire and further increase the political risk associated with the project.

Given the asymmetry information that exists in many regulated industries and in contract negotiations (Auriol and Picard 2013), if a satisfactory PPA can be negotiated to repay the financing for an overstated investment cost, this will allow for an increase in the absolute amount of borrowing. Inherent in the cost recovery is the robust cash flow structure, centred on take or pay terms (Di Bella and Grigoli 2017). “Take-or-pay” contracts are common in the energy sector. They provide comfort to investors in large energy projects (and their creditors), so that a reliable revenue stream will occur in every state of the world, ensuring the project's profitability and the repayment of debts incurred. Proponents of these arrangements argue that they facilitate investment that would not occur otherwise, in particular in environments perceived to be risky. However, if the dispatch centre does not use cost as a criterion in deciding what generation units will be used and when, price signals will be distorted. Thus, the incentive to invest in generation technologies that ensure minimum costs is absent, potentially creating a barrier for new entrants and imposing a cost for the economy. Problems arising from these arrangements could be particularly severe in fragile contexts, where take-or-pay clauses may be abused either due to weak government capacity, governance issues, or both (Di Bella and Grigoli 2017).

Therefore the balance of the actual investment cost that is provided by the equity will become smaller than what the IPP would have contributed in the absence of an overstatement. An inflated investment cost that is financed will allow the IPP owner to collect the margin upfront, usually through non-arms length construction contracts (Kashi 2015). PPAs are negotiated based on the stated investment costs put forward in the proposals submitted by the potential IPPs and are expected to be reviewed by experts. This implies that an institution staffed with highly qualified experts to evaluate these proposals is important to control and minimise the possibilities of overstated costs. Banal-Estañol et al (2017) whose studies show the successful electrification of Latin American countries also stress the need for such institutions and further suggest that to implement these sophisticated regulations and provide some credible commitments to foreign investors, most countries created independent regulatory agencies, with highly qualified staff and with a strong organisational autonomy.

Balza et al (2013) show that in Latin America, the intensity of private investment in the power sector was not significantly related to an increase in coverage. In spite of this, investment in electricity did increase the quality of service and the efficiency of its generation, with a reduction in electricity losses and an expansion of generation capacity (Banal-Estañol et al 2017). In addition, price regulations and subsidy schemes were established to allow fair conditions for domestic consumption, regulated users and the financial sustainability of firms (Levi-Faur and Jordana 2006).

In the market for long-term power purchase agreements (PPAs), competition is only present at the bidding stage. Even then only a limited number of bidders are present, and creating a competitive environment remains a challenge in many developing countries. Furthermore, if this is the way that all the bidders manage their risk, there is little reason why this investment cost mark up will be reduced with more competition. Phadke (2009), using data from 41 combined-cycle power plants in 8 countries in Asia and the Middle East, shows that the stated investment cost of IPPs in developing countries is up to 50% higher in the absence of competitive bidding. As he noted, this does not necessary mean that the introduction of competitive bidding can reduce the investment costs by 50%. Some countries are simply unable to attract investors into the electricity

sector under competitive procurement processes. Phadke (2009) provides a formulation. This formulation and example show that a slight overstatement of investment cost will have a considerable impact on the return on equity.
From Table 8.1 adapted from Kashi (2015), row 5, shows that an overstatement of the investment cost by 12% will double the rate of return on equity (Guasch et al 2006).

Table 8.1

Return on equity for different levels of mark up

	Markup on actual investment (λ) (1)	**Share of debt in actual investment cost(d x(1-λ) (2)**	**Actual return of equity (ROE_a) (3)**
1	0%	80%	20%
2	3%	82.4%	23.4%
3	6%	84.8%	27.9%
4	9%	87.2%	34.1%
5	12%	89.6%	43.1%
Source: Phadke (2009) and Kashi (2015)			

Table 8.1 reports that an overstatement of investment costs as low as 6% would reduce the share of actual equity financing from 20% to 15% of the total investment costs of the project and increase the rate of return on the owner's net contribution to the financing from 20% to 27.9%.It is far easier to increase the return by overstating the investment cost rather than increasing the target rate of return for equity in the PPA contract, which can easily be compared with other projects and hence creates significant political risk (Kashi 2015). A typical example is the Ameri IPP and Government of Ghana. The contract terms showed that the EPC Deferred Payment Facility Agreement entered into

between Ameri Energy (as the Developer) and PPR (as the contractor and financier) states that the total financial obligation of the project over the 5-year period is a maximum of US$360 million whereas the BOOT Agreement shows a minimum of $510million (Annex G of BOOT). Effectively, Ameri Energy is making a commission in the sum of US$ 150 million over the term of the Agreement. Additionally, the Agreement incorporates a variable charge of $0.005 cents per kilowatt hour which totals $16.6m. While the rate is reasonable the total annual fixed figure of $16.6m is erroneous (Ministry of Energy 2017).

As a result of this overstatement, the charges to the buyers of the electricity throughout the PPAs will be increased. The capacity payments to investors will be increased in absolute terms and, at the same time, the net financial contribution of the IPP owners will shrink. This results in a faster recovery of the actual amount of equity contribution that is a critical factor in determining the attractiveness of the project, as expressed by the payback period.

It is also important to note that such overstatements are not visible in the operating costs charged to electricity buyers. Maintenance costs are negligible in most power generation projects and there would have to be a very substantial overstatement to make a difference. Fuel cost, although a large portion of the total cost for most thermal technologies, is treated mostly as a pass-through to the public utility and in Ghana in the various contracts the Government took the fuel supply risk. For example in the Ameri BOOT agreement, the Government of Ghana (GoG) is responsible under the Agreement, for the supply of fuel to the plant in accordance with the agreed specifications, relating to quality and pressure. This arrangement makes it similar to a tolling Agreement where fuel supply is not the responsibility of the plant operator. Under tolling arrangements, the operator is not obliged to use fuel that is out of specification. There is a high tendency for operators to refuse out-of-specification fuel under tolling arrangements even though this fuel could be used within the units' tolerance range.

In the event that the operator refuses to accept out-of-specification fuel, for as long as the plant is declared by the operator to be available, a tolling arrangement would continue to place an obligation on the Government of Ghana (GoG) to pay the capacity charge in spite of energy not being generated by the operator. This could create fuel disputes and avenues for a rogue operator to engineer a situation whereby the fuel supplied by Government of Ghana (GoG) is "never compliant" (Ministry of Energy 2017).

Even if it is a part of the energy payment to the IPP, the fuel cost is a function of the plant's total output, generation efficiency, and the market price of fuel, all of which are easy to measure and known by all stakeholders.

The end result is an increase in the cost of electricity to the country and an increase in the levels of finance required by the institutions financing the project. The country has to pay a higher price for the generation capacity, which in turn distorts their choice of technology and can result in an inefficient mix of inputs for electricity generation. Reliance on more fuel will lead to higher lifetime costs for the same amount of electricity generated. This is not a concern for the IPPs as the fuel cost is passed through to the distributors of the electricity. The IPP owners will recover their equity financing contribution at a faster pace.

Kashi (2015) whose study included Ghana provides a more systematic explanation for the tendency towards the overstatement of investment costs, with particular attention to the role of country risk. The results of this study show that private sector IPP owners, in an effort to mitigate their risks in high-risk countries, have significantly increased the stated investment cost of proposed power generation plants. Furthermore, the private investors have an incentive to invest in power plants with lower technical efficiency, as the mark ups can be higher on plants with lower price tags. The practice of IPPs marking up the investment costs to mitigate the country risk means that electricity system planners are faced with distorted input prices that cause them to choose less efficient technologies in long-term system expansion planning.

8.5.2: Implications for Eliminating Capacity Shortness: Actions and Outcomes

With an increased investment cost, to compensate for the perceived cost of country risk, the system moves to less efficient power plants. This increases the cost associated with the fuel component of the system operating costs. This analysis points towards the potential financial and economic benefits that could be realised through the use of political and country risk-management products offered by international and bilateral financial agencies to mitigate these risks in project financing arrangements of IPP investments. The process of providing

these risk mitigation instruments will need to be carefully sequenced so that the investment costs are reduced to reflect the effect of the risk mitigation.
In the absence of competition it is conceivable that these risk-mitigation Instruments would be acquired and the costs incurred by the consumers through higher PPA prices, while at the same time the private sector builds in compensation for these risks through higher capacity costs.

Kashi (2015) asserts that the efficiency rating of plants in high-risk countries is lower, even after factoring for the scale effect. The results suggest that if the country risk is on a scale from 1 to 17 (AAA to CCC+), with Ghana's ranging between BB+ and B- from 2007 to date (Standards and Poors 2018), IPPs would opt for 0.2% less efficient CCGT technologies on average for every step of country risk. Note that this regression was performed on CCGT power plants only (66 observations) with an efficiency range from 49.7% to 60.2%.

Guasch et al (2006) provide further insights into the rationale for an effective regulatory design. They argued that time after time, attempts have been made, particularly by incoming administrations, to question existing concessions and to dismantle regulatory setups by previous administrations-often for political rather than technical reasons. Such efforts significantly increase regulatory risk, translating into higher tariffs or lower transfer values. Other forms of interference involve interfering with budgets, salary scales, and the like. Thus, the cost of regulatory uncertainty will be directly reflected in the proceeds that can be realised by awarding private concessions or in the tariffs that must be charged in order to cover the debts that have accumulated by the existing operators. Reducing regulatory risk requires an adequate regulatory framework, a credible commitment to the stability of the regulatory framework, and predictability, with the usual caveats, of regulatory decisions (Guasch et al 2006).

This requires a strong legal grounding - preferably on a law detailing the regulatory framework, a significant amount of autonomy of the regulatory agency, and a hands-off approach by the government in regulatory decisions (Guasch et al 2006). Regulatory frameworks and agencies in legislation rather than administrative procedures or presidential decrees are preferred because laws are much harder to overturn or modify than decrees and contracts.

In keeping with the findings by Kashie (2015), the risk of financial and economic exploitation, the sequencing of injecting various generation technologies needs to be properly thought through and should be done proactively ahead of changing economic and social conditions in developing countries who have no means to manufacture power generating equipment. This also suggests that countries in Sub-Saharan Africa need to reconsider their technology choices and opt for better financial and technical arrangements in future thermal-generation IPP projects, put in place an effective and independent regulator backed by law to enforce price caps and provide advice and policy framework on subsidy management. Otherwise, in their efforts to meet the challenges of growing demand for electricity, the electricity system planners in these countries will be saddling their consumers or government budgets with high generation costs over future decades because of ineffective procurement and risk-mitigation strategies in their current dealings with IPPs. In developing countries the risks allocation hinges largely on the government and the guarantee are required to satisfy the underlying principle of bankability.

Tools used by governments are the form of guarantees, waivers, compensations, and special status for financiers. One of the main features of guarantees is that they extend the maturities of debt instruments in developing countries. Also through making projects viable, guarantees provide countries with experience in dealing with international private capital providers and in using extremely complex financial structures.

The European Investment Bank (EIB) through its advisory arm, the European PPP Expertise Centre (EPEE) (2011) shows that in an attempt to secure equity investments into the power sector governments proactively underwrite these investments. Guarantees may be structured as financial or refinancing guarantees. This experience speeds up financial market development and enables the borrowing country to build a track record. There are additional benefits such as the attraction of private investors and reduction of pressure on budgetary resources. Again the countries' borrowing levels are not affected when funding comes from private sources.

But some risks in project finance-commonly referred to as force majeure risks-cannot be contractually allocated. These risks are associated with fire and natural disasters, and they have to be dealt with by the purchase of insurance.

International Finance Corporate (IFC) requires that all its projects have adequate insurance to cover such risks (Finnerty 2013).

Government underwriting takes the form of state guarantees (SG) in the financing of projects. SGs are defined as agreements under which a sovereign or assimilated entity ("Government") agrees to bear some or all of the downside risks of a typical power project. An SG is a secondary obligation. It legally binds the Government to take on an obligation if a specified event occurs. An SG constitutes a contingent liability, for which there is uncertainty as to whether the Government may be required to make payments, and if so, how much and when it will be required to pay.

At the wider programme level, SGs can create moral hazard as the market may get used to SGs and expect them regardless of individual project circumstances. Additionally, SGs can create two tiers of projects, those that benefit and those that do not. The latter may find it more difficult to attract private sector interest and/or financing (EPEE 2011).

To avoid moral hazard, it is fundamental that the design of SGs should leave the private sector with sufficient risk at the margin. Partial guarantees can limit moral hazard. This can be achieved in many ways, such as (i) setting ceilings on government exposure, (ii) restricting the SG coverage to specific events or specific project phases, (iii) limiting the guarantee coverage to a sub-group of lenders, (iv) requiring the Government claims to rank above those of the lenders or the investors in the event of a default and (v) once an SG is called, requiring government payments to become loans rather than grants.

Governments should avoid incurring implicit liabilities or promoting a guarantee culture. This can best be achieved through clear statements to the market and ensuring that actions are consistent with those statements. Where governments offer SGs, what is guaranteed and what is not should be made clear. Governments also need to recognise that they may come under pressure from lenders and sponsors to act beyond these boundaries when projects run into trouble. Governments should have a clear strategy for this eventuality. Ad hoc policy-making may result in bad precedents

8.5.3 Implications for law and regulation

The introduction of future public private partnership law should take into account the issue of sovereign guarantees. The use of sovereign guarantee should be aimed at achieving three main objectives: (i) encourage more long term flows, (ii) counteract the increased risk aversion due to the recent contract breach by some host governments and (iii) create a more solid practice in Ghana to assess infrastructure project risks and strengthen its financial expertise. In terms of policy, SGs should therefore ideally be temporary and reversible.

At the project programme level, the Government should clearly state the features of the SG scheme at the outset in order to guide the market and manage expectations. Ideally, the Government should indicate a start date and an end date for the granting of the SGs and indicate the circumstances under which it envisages that an SG will no longer be necessary. At PPP project level, the SG structures should address the periods of the project cycle that require Government support. SGs should contain provisions for the expiry of the cover once the critical project phase is over. Financial benefit sharing mechanisms can incentivise the power project and its lenders to step down an SG when it is no longer needed for the economics of the project.

In area of law, since most financing will demand co-guarantees from the Government of Ghana(GoG) the provisions on guarantees must be benchmarked against the Multilateral Investment Guarantee Agency (MIGA) standards to cover the respective contract of guarantee for loan guarantee; for shareholder loans; for non -shareholder loans; and equity investors. Benchmarking the law on the framework of MIGA would promote assurance and transparency and can leverage on MIGA as an institution. This can also mobilise additional coverage through coinsurance programmes with other political risk insurers, through its Cooperative Underwriting Programme.

MIGA has no minimum investment amount (MIGA 2011). The law must recognise subordinated loans as it promotes earlier repayment of their ‘equity funding’ than would be the case if potential investors subscribed to those funds for shares as ‘true equity’ and received dividend payments.

8.6.0 FINANCIAL AND FISCAL REARRANGEMENTS FOR CAPACITY ENHANCEMENTS IN GHANA

Additional financial and fiscal measures are needed to accelerate the strategic objective of eliminating capacity shortness in several developing countries like Ghana.

8.6.1: Theoretical and Empirical Literature

According to Amendola et al (2018) fiscal policy is among the most important means through which governments influence the business cycle. They argue that sound fiscal policies can promote sustained and inclusive development and reinforce both social and economic stability. They further suggest that tax expenditures, which are fiscally equivalent to more traditional forms of public spending, can play an important role in attracting specific types of private investment and rewarding the production of positive externalities. Tax expenditures include tax exemptions, deductions, tax holidays, and other policies that reduce the tax liability of specific sectors, firms, and individuals which are currently incorporated in the Ghana's tax incentive scheme.

They however criticize the unique features of tax expenditures that have made them both popular and controversial. From a public policy perspective, unlike public spending, tax expenditures are embedded in the tax code and are not recorded as outlays in the annual budget. They increase the complexity of the tax code, which raises both the private cost of tax compliance and the public cost of tax enforcement, while expanding opportunities for fraud.

Again, although tax exemptions are often intended to advance worthwhile policy goals, their public benefits can be difficult to gauge, while their private benefits create a strong incentive for firms and investors to lobby for preferential tax treatment, even when such treatment serves no clear policy objective (Amendola et al 2018). In keeping with Sebastian (2014), Ghana's fiscal incentive framework is skewed more towards profit-based tax incentives as opposed to cost –based tax incentives.

According to an IMF et al (2015) study, profit-based incentives tend to be less effective in encouraging investment compared to incentives that reduce the capital cost if profitability is low. Again, where profits are earned due to the presence of location-specific factors, such as natural resources, agglomerations, or local markets, profit –based incentives tend to be associated with high redundancy rates and are again ineffective in raising investment. Cost-based tax incentives involve specific allowances linked to investment expenses, such as accelerated depreciation schemes and special tax deductions and credits (Daniel et al 2009).

8.6.2: Implications for Eliminating Capacity Shortness: Actions and Outcomes

Because cost-based incentives are targeted at lowering the cost of capital they make a greater number of investment projects more profitable at the margin – meaning that it may generate investments that would not otherwise have been made especially with solar power investments. Again in keeping with Sebastian

(2014) and Anderson (2009) the tax and fiscal stability clauses should be shifted from the freezing type to economic equilibrium type given the macroeconomic dynamics in Ghana. Economic equilibrium provisions provide for adjustments of the fiscal terms, to assure investors that a change in law does not have a material adverse impact on the power generating firm under the purchasing power agreement (PPA). It therefore represents a specialised adaptation clause addressing economic hardship arising from a change in law (Owen 2009).

Again the freezing structure for power producers in the free zone with respect to tax holidays is undermined by the absence of sunset provisions. Firms may seek to roll-over a tax holiday period or by incorporating a new firm that may qualify for it especially where the infrastructure is divisible like solar projects. A tax holiday may become a de facto permanent tax-exemption –a practice that should be avoided. Because tax incentives are negotiable and provided through agreements, regulations and the like, they escape oversight and can be become prone to undue influence and preferably consolidated into law to promote transparency and accessibility (IMF et al 2015).

Renewable energy from solar and wind seems to attract similar fiscal and financial incentives in many countries. A comparative analysis shows that the main incentives include capital subsidy, grant or rebate; reduction in sales, energy, CO_2, VAT or other taxes; production payment and public investment loans or grants(Sakah et al 2017). A successful renewable generation country like Germany (Mabee et al 2012; Sakah et al 2017; Tangeràs 2018) provides all the stated incentives except reduction in sales, energy, VAT or other taxes, while China provides all the incentives. Tangeràs (2018) who shows that Germany is a leading example of a country that has started a transition to an electricity market based on renewables and that approximately one fourth of the country's annual electricity generation came from renewable sources in 2014 compared to 6% at the turn of the millennium .The UK provides incentives for production tax credits, production payment and public investment loans or grants. Ghana comparatively provides capital subsidy, reduction in VAT and public investment loans or grants.

A major distinction between the Ghanaian and German fiscal and financial incentive schemes is the feed –in tariff (FIT) which is 0.06 and 0.13 USD/ kWh for wind power in Germany (Mabee et al 2012; Sakah et al 2017) and Ghana respectively and 0.28 and 0.15 - 0.17 USD/ kWh for solar power in Germany and Ghana respectively (Sakah et al 2017). Feed-in –tariff is a guaranteed payment of a fixed price per kilowatt-hour (kWh) of electricity to renewable energy producers.

While Germany provides a guaranteed period of 15 -20 years, Ghana offers 10 years and it is reviewed every two years. Moreover, priority grid access is available for renewable producers while the same does not exist in Ghana (Sakah et al 2017). The lessons for Ghana is to structure its renewable portfolio standards (RPS) in terms of enforcing quotas evidenced by tradeable green/ renewable energy certificates (REC) as found in China and India and because Ghana is capacity short policies should be focussed on measures that will promote access to infrastructure, funding and technology because the inputs have no costs.

Again it can ignite private sector participation if the needed tracking and verification to ensure compliance are implemented. Even though the FIT came into force in 2013, followed by the Ghana Accelerated Depreciation policy issued in 2014 which is a cost-based tax incentive mechanism currently in force (Sakah et al 2017), the other policy measures are yet to be implemented. For example, the Ghana Renewable Energy Purchase policy, Ghana Biofuel Blending Mandate policy, Ghana Renewable Energy Fund policy were issued in 2014 as part of the energy market mechanism. However, the aforementioned policies and the Net Metering Scheme (2015) have been proposed but are not in force.

There is the need for two major financial rearrangements to be sequenced to eliminate the capacity shortness. The first is, attempts have never been made to seek domestic private capital but rather borrowing by the government to subsidise energy bills which is a financial and fiscal policy misfit. In the short term, attention should also be directed at establishing institutions that will tap into both international and local resources to support the development of the energy sector. Since the energy projects require long term and stable source of funds at the initial stages, the pension law should be changed to allow specific allocation of the accumulated funds into energy projects which will contribute to the overall quality of life of people.

The second is the development of institutions that provide conduits for investors to exit from the energy sector. Practically, one major channel to increase the flow of capital into the power sector is to provide a channel for investors to enter and exit without any regulatory barriers. The capital market should be backed by an institutionalised fund or an escrow account managed by the Bank of Ghana to support the capital market segment that relates to the sale of power sector shares or investments. Such a structure will effectively give value to regulatory puts that foreign investors require. Regulatory puts will allow an investor to be assured of his investment not being affected by any changes in regulations that may affect the project. By offering regulatory puts, investors are incentivised to maintain their investments to reduce the extent to which contingent liabilities will be made if the put is exercised as a result of any regulatory changes.

Likewise it will also link up with the opportunities offered by the use of bilateral and multilateral financing and counter-guarantees from the International Finance Corporation (IFC) and the World Bank. There is also the added role of these investment institutions to support the new ideological framework of allowing private sector participation in the power sector. These financial measures can in the long run reduce the cost of capital given local participation and commitment of the population to develop the power sector for the societal advancement.

8.6.3 Fiscal Policies

Sovereign guarantees (SSGs) entail a fiscal risk which should be managed. In particular, sub-sovereign government entities or agencies will often be willing to grant SGs or make use of central government SGs whilst underestimating the potential cost of SGs for the central government. As part of a policy, a proper decision-making framework for granting SGs should be adopted. Information on SGs should be centralised. The Ministries of Finance should play an active role in developing and reviewing SG proposals. As the issues involved in evaluating, designing and valuing guarantees are complex, it will often be necessary to appoint financial and legal advisers. Governments should also consider limiting their exposure by setting quantitative ceilings for SG programmes and caps for specific SG instruments. This can be achieved, for instance, by using a fund such as the funds raised from the taxes on energy under the Energy Sector Levy Act (ESLA), 2016 to manage liabilities arising from SGs. This law has to be revised to include the specific allocation of the fund for the various segments such as gas infrastructure and grid development among others.

Additional tax benefits in terms of reliefs should be given to individuals who buy power sector shares and remittances from their sales abroad should be tax exempted. All taxes on the gas–power value chain should be taken from the end-user. This will reduce the cost of inputs. Again, it will link fiscal performance in terms of reduced subsidies to the performance of the distribution system. Inherent in these measures is the need to amend the payment law, the Bill of Exchange Act, 1961, Act 55. The law should give the priority of settling electricity debt second to salaries, even in a liquidation state. This will improve bills collection because of the abuse of payments through the use of cheques to settle bills which can be dishonoured to allow the debtor to buy time.

8.7.0 CRITIQUE OF THE REGULATORY REARRANGEMENTS FOR ELECTRIFICATION

The main critique is that the normative recommendations have assumed that policy makers in capacity short economies like Ghana have the same level of awareness and the politicians attach the same discount factor to define the specific timeframe and the associated economic impact of capacity shortness especially in Ghana. Again not all the trade-offs have been captured in the normative analysis. However, capacity shortness has become one of the political issues in elections in Ghana and therefore going forward, the social, economic and political pressures will call for an induced integrated approach to eliminate capacity shortness through the proper sequencing of the needed reforms.

Where the phases of inception, take-off and mainstreaming of reforms do not have well- defined sunset periods, mandates and are further non-compliant with energy cost delivery standards the effect is that cost recovery mechanisms are likely to be limited to public budget or borrowing by government to finance energy debts. There can be revenue losses from energy efficiency activities via tracking accounts, revolving fund and / or credit lines for energy efficiency activities, partial risks guarantees, time of use tariffs and on –bill financing or full prepayment schemes. It is yet to be seen how future restructuring which should have schemes for compensation for revenue losses arising those activities mentioned above will impact the financial sustainability of the Ghanaian power sector.

8.8.0 CHAPTER SUMMARY

The empirical evidence shows that there are processes and challenges that countries face in their attempts to eliminate the gaps in their capacity levels, generation and accessibility of electricity. In Ghana, these proceses and challenges have had both resource law, energy law and some policy implications. Measures needed to correct the imbalances, run from the immediate period to long term. A school of thought requires a gradualist and an integrated approach to resolve the issue to avoid a non –cooperative equilibrium.

Specific measures such as an institutionalised independent regulator and strengthening the Energy Commission to play its required power planning role towards the management and optimisation of the electricity generation mix strategy of the country are required immediately.

Simultaneously, the revenue collection cycle within the power distribution value chain should be made viable to ensure the solvency and create a confidence factor through financial sustainability of firms in the value chain. Furthermore by creating financial and fiscal space to give the power sector planners the opportunity to auction the expansion of the generation gap in a way that will mitigate the risk of overinvestment and poor choice of technology will avoid the inherent possibility of wasting the newly found gas reserves.

Finally, such a crucial measure will provide further resources to expand the grid and transmission system on a continuous basis. It should not be forgotten that the medium to long term electricity security of supply will depend on the structures which will allow for the recycling of wealth in the power sector through institutions including investment bodies and the development of the Ghanaian capital market by changing the current Securities and Exchange Commission Act 2016, Act 929 to accommodate these new potential needs of the country.

The next chapter will discuss the contribution of the research to resource and energy law and policy, its limitations and scope for future research.

CHAPTER 9

CONTRIBUTION, LIMITATIONS AND SCOPE FOR FUTURE RESEARCH

9.1.0 INTRODUCTION

This chapter discusses the conclusions of the thesis. It seeks to achieve three main objectives. First it summarises the key research findings. Second, the contribution to research, management practice, law and policy in energy will be identified. In this regard some policy suggestions and their limitations if they are to be implemented in Ghana are further discussed. Third, the research limitations and avenues for future research will also be identified.

9.2.0 KEY RESEARCH FINDINGS

The results of this study show that the using the contribution of various power generators as a proxy for ESoS in Ghana, two critical factors which influence power availability are the size of the installed capacity and the sustainability or endowment characteristics of the generators. This suggests that the endowment theory and the ladder theory are relevant to the Ghanaian situation. Electricity sector regulatory characteristics including regulatory substance and governance, the level of power prices and ownership do not significantly influence the level of power supply because the state-owned plants are influenced largely by their political agenda, whilst the IPPs are covered by the power purchasing agreements. This has exposed the country to huge energy sector debts currently financed through energy bonds to be repaid in future, thereby creating a new phenomenon of energy injustice against the unborn generation.

Further analysis using the Blinder –Oaxaca decomposition also suggests that state-owned generators in Ghana exhibit relatively higher levels ESoS compared to IPPs generators. Again renewable source of energy is still the most significant factor determining the electricity security of supply in terms of financial and input considerations. This is followed by size, which implies that the capacity expansion should be geared equally towards hydro and renewables and not only thermal. The added advantages are that in the very long term, the renewable infrastructure like hydro lasts longer, they remain as domestic resources, will have little or no geopolitical challenges and do not get depleted.

The import of the Blinda-Oaxaca decomposition is that, it reinforces the need to put strategic planning lenses on generation mix in all circumstances once a country does not manufacture the equipment that generates power. The findings also show that proactive planning and implementation are needed to optimise the generation mix because of the difference in the gestation period between hydro plants which are cheaper for Ghana than thermal which for its optimisation demand proper procurement process and management to avoid overestimated investment costs.

In keeping with Williams and Ghanadan(2006), Gratwick et al (2008) and Zaman and Brudermann(2018) the policy implications of these findings suggest that nine sequential elements or milestones: corporatisation and commercialisation, electricity laws, a regulatory authority, independent power producers, functional disintegration, privatisation of distribution and generation and wholesale and retail competition of the power sector should be implemented in depth and in a properly sequenced manner given the current poor configuration of the power sector in Ghana and the fact that the initial basic model was state ownership monopoly. To undertake the reform of existing reforms will imply that in the long term, Ghana will have an effective hybrid system which minimises the risks associated with privatisation and maximises state ownership where social welfare issues are considered. In keeping with Barrett (2016) the following step-by-step approach to reforming the current reforms are suggested. The first is that the state-owned energy firms should be given time to reorganise themselves and get ready for competition. Secondly, the sequential framework and the level of developing the internal energy market should be defined and effectively communicated.

Given the current quality of regulatory substance and governance, a legal framework that will ensure not only the independence of the regulator but one granted with enforcement powers with adequate autonomy, adequate skills and the capacity to deal with practical implementation challenges become very necessary or critical. The implementation challenges which include the settling of disputes concerning contracts, negotiations and the refusal to provide access to infrastructure or supply electricity therefore become the critical success factors. Stiff governance requirement to prevent the capture of regulator by preventing senior staff of the regulatory authorities to take appointments with the regulated firms should be in place. These measures do not exist in all the laws passed to date to support the reform process in Ghana. Their implementation will be necessary to prepare the grounds for further market opening required such that all customers are free to choose a supplier in Ghana in the very long run.

A key prerequisite to reforming the distribution sector is to assess the adequacy of the transmission ownership unbundling in Ghana which still remains in the hands of the government with private participation not considered yet. Riding on the shoulders of Barrett (2016) more transmission infrastructure is needed to ensure electricity security of supply and the law allowing for private participation should be allowed for minority participation. The accompanying shareholder rights should be limited to the receipt of dividends. This protects public interest while satisfying the minimum investor expected returns with guarantees from the government. The transmission entity should be an independent transmission system operator. The reforms should empower GRIDCO to extend and implement activities relating to the granting and managing third party access to the system; collecting access charges, congestion charges and payments under the compensation mechanism; maintaining and developing the transmission system and investment planning. These should complement its current active role in the Ghanaian energy market with the responsibility for guaranteeing electricity security of supply, dispatching electricity producers, balancing markets and transporting electricity. Their enforcement also brings into question the totality of electricity laws relating to optimisation of technology and investments that relate to the base load supply.

Ghana being a signatory to The Paris 2015, the opportunity to secure significant base load from renewables, requires that a robust socio-political framework aligned to the resource endowment of Ghana is put in place.

This will further induce the need to reform the current reforms in the Ghanaian electricity sector. Such reforms should aim at ensuring that proper credibility of the institutional endowments promotes security, innovation and sustainability. Specific reforms should strengthen measures currently in use to attract investors into power project financing. In keeping with (Rodilla and Batlle 2012), these measures should be revised with a strong institutional framework with adequate information on the effective demand for power levels, and some fiscal space to complement revenue that can be generated downstream to support the negotiation process

More importantly is the issue of creditor’s or financiers’ rights. The reforms should take into account the following four powers of secured lenders in bankruptcy: (1) whether there are restrictions, such as creditor consent, when a debtor files for reorganisation; (2) whether secured creditors are able to seize their collateral after the petition for reorganisation is approved, that is, whether there is no automatic stay or asset freeze imposed by the courts; (3) whether secured creditors are paid first out of the proceeds of liquidating a bankrupt firm; and (4) whether an administrator, and not management, is responsible for running the business during the reorganisation. The comparative Bankruptcy and Insolvency Act 43 of 2007 of Saint Vincent and The Grenadines for example captures these important features in sections 11 to 23 and 102. Ghana's Insolvency Act 153 of 1962 has to be revised to ensure that these powers are provided to protect secured lenders in the energy sector.   The provisions made in the Lenders and Borrowers Act 2008 and Bill 2017 are inadequate to satisfy the huge investment risks in the power sector value chain.

Privatisation of distribution, generation, and promotion of wholesale and retail competition in Ghana can yield the expected effect if the energy law promotes private ownership, strengthens creditor and ownership rights to recover revenues and investments, undertake contract of sale within a set regulatory framework.

This is necessary to benchmark the minimum and maximum returns that can be offered to an investor. Again such a framework will allow the authorities to review the quality of plants established, their efficiencies which relate to the usage of gas resources, gas input risks which are often taken up by the government of Ghana.

In Ghana like many developing countries which may be fortunate to have domestic gas resources and an abundance of sunshine and river bodies, power sector reforms should lead to legal, regulatory, financial, and fiscal rearrangements in a simultaneously but synchronised manner. Such rearrangements would help to manage the interest of the constituent investors and stakeholders in the Ghanaian power sector if the principles of sequencing identified and enumerated in this research are applied.

9.3.0 CONTRIBUTION TO LITERATURE

This research contributes to the literature in several ways. It contributes to a strand of literature which looks at how new institutional economics (NIE) has been applied in a jurisdiction in keeping with Erdogdu (2013) and Prévost and Rivaud (2018). It also contributes to a strand of literature that attempts to integrate the two different branches within the NIE, the neoclassical institutionalism and the plural-disciplinary and historical analysis of institutions and law, with particular attention to legal pluralism or diversity starting with Deakin et al (2016) and Prévost and Rivaud (2018).

Furthermore, it contributes to a strand of literature which uses the endowment of the country to analyse its electricity security of supply. This thesis therefore complements the recent work of Burke (2010), Kileber and Parente (2015), Di Bella and Grigoli (2017), Best and Burke (2018) although a different methodology has been adopted and the granularity of data is different in defining the power market performance factors. It contributes also to the strand of literature in electricity studies which stresses on the role of technical efficiency in energy security. The research is based on the assumption that the accounting and production data used is reliable. Therefore, the findings from the research contribute to the strand of literature which links the production of power to the final provision of power to the consumer or quality of service as an integral and the proxy for quality of electricity security of supply and their regulation starting with Röpke (2013) and Arlet (2017). Therefore the findings support the strand of literature which suggests that investments in power grid systems are as critical as those put into the generation system to minimise losses and if the needed quality of electricity security of supply is expected in capacity short economies.

Again, the Blinder-Oaxaca decomposition has been widely used in the social science literature, to explain differences in outcomes for different groups, and its application to electricity literature is limited. This study therefore makes a methodological contribution to the strand of literature which uses the Blinder-Oaxaca decomposition to provide insight into the relative performance of IPPs and state-owned power producers even though it was differently used by Marikawa (2012) in Japan in analysing urban level usage of electricity and Antoni et al (2015) in Germany to evaluate the premium on earnings of staff in the renewable sector. Therefore, this research is one of the pioneers to apply the Blinder-Oaxaca methods to explain the production gap and or ESoS contribution differences between IPPs and state-owned power generators in Ghana. It uses the Blinda-Oaxaca decomposition to justify the need to anchor the development of renewables in the design of Ghana's electricity security of supply despite the growing gas resource, their discoveries and economic case its use in power generation.

This is one of the first major works that examines the electricity security of supply in Ghana by generator or supplier mix over the period 2007 to 2016. It fills the gap in the extant literature by comparing the ESoS from 2007 to 2012 and from 2013 to 2016. The comparison has provided insights into the significance of the varying levels of power generation through the intensive use of thermal generation using gas as against overreliance on hydro power in Ghana. It provides the first direct evidence of the relationship between firm–level and regulatory variables and electricity security of supply in Ghana. The study therefore contributes to knowledge by advancing incrementally the understanding of the level of security of supply contributed by power generators in Ghana. It also adds some revelatory information in the form of the effects of firm-level risk factors or characteristics and regulatory variables on the performance of the Ghanaian electricity sector. It complements the recent work of Prévost and Rivaud (2018) by stressing that the long term cost of not placing renewables as the anchor or the central theme of Ghana's electricity generation mix would not only conflict with the neo institutional economics paradigm which supports green energy and accountability for externalities but also reduce future potential investments into Ghana's power sector development.

Again, the period of study makes this thesis contribute to post-unbundling literature on power sector activities in Sub-Saharan Africa. In other words, the study is also timely given the recent reforms in the power sector or industry in Ghana and their potential impact on electricity security of supply. Although, there are a number of studies on the power sector in Ghana, the other studies focus largely on unbundling and potential regulatory measures and do not cover the issues addressed in this study such as issues relating to sustainability, factor endowments and their interaction effects with their factor coefficients.

It complements the strand of literature that examines the impact that IPPs have on electricity security of supply on their host countries especially in developing countries starting with Phadke (2009), Kashi (2015) and Eberhard et al (2017). Again the ESoS scores used is a simplification of measuring plant efficiency or contribution to electricity security of supply in a capacity short and developing economy and it is an extension to the use of capacity factor in the literature as pioneered by Nicholosi and Fũrsch (2009) and Petitet et al (2017).

9.4.0 CONTRIBUTION TO MANAGEMENT PRACTICE

The main contribution of this research to energy management practice is that capacity shortness is still being tackled on an ad hoc basis in Ghana and the long term cost of contracting IPPs may be realised when the full costs of production and control have brought an unbearable cost on the state because policies set to regulate (measure, value and optimise the use of resources) and to ensure proper capacity management through auctioning are not in place yet. Again attracting investments into power generation requires that all transaction costs inherent in the long term contractual nature of all the projects needed to eliminate capacity shortness are fully addressed. The research stresses that it is not only production but two additional elements are needed to ensure sustainability of the power sector. The first is the degree of losses that are extremely high and therefore the policy should focus on encouraging investments into the transmission segment in addition to encouraging the unbundling of the distribution sector from three angles.

The first is to ensure that private players have standardised the billing and metering of power to various users to ensure the effective billing and collection of tariffs. The government itself must have a policy that requires ministries to directly pay their bills instead of the traditional cross-table meeting and netting procedure currently being used. This limits the liquidity of the market.

The second is to ensure that power trading mechanisms are instituted. By developing trading mechanisms whereby power can be purchased as a commodity for profit after having a measured grid and credible billing and collection system and structure in place. This will also reduce the lag involved in the current collection of revenue from the ECG, now PDS and NEDCO and remove the viscous cycle of revenue loss, which leads to subsidies, crowding out of private investments and reduction in economic growth.

The final is to allow private capital through the Ghana Stock Exchange by floating shares on some portions of the government holding in energy assets. This will reduce the budgetary burden on government and provide funding to repay the huge energy bond to be floated to defer the final settlement of accumulated energy debts. That could be a temporary measure. But that will not solve the solvency problem facing the sector. The electricity sector should be designed as a viable chain of business networks with strong investment bodies being integrated in the value chain for financing, monitoring and reforming the sector through internally induced demands to complement the effort of any independently appointed regulator. In short, power management is a combination of finance, law and economics. Legally the law must be strengthened to make it illegal to transfer funds raised for energy related projects and payments to generators be diverted into other expenditures. Again there is the need to manage the subsidisation process by requiring that users who are subsidised should pay and claim rather than they been given the subsidy in advance upon purchase of power as one finds in France. These measures will promote the culture of recognising energy as an essential commodity which needs to be valued.

9.5.0 CONTRIBUTION TO LAW AND REGULATORY POLICY

The research makes a contribution to law and policy from four angles: gas law and policy; project financing investment attraction and investment laws; power sector regulatory framework; the payments system law and policy measures in downstream power sector management.

In the area of gas law and policy, the research suggests that the role of the gas aggregator for demand and supply should become more strategic to ensure the long term development of the gas sector not only for power generation but also should domestic production grow in excess of demand, the export side could also be developed systematically. On the other hand should domestic production continue to fall short of supply, the aggregator is expected to ensure the development of liquefaction plants and LNG imported for power and other uses are applied in the best interest of consumers and users. In the short term where the entire gas output is going into power production, given the solvency problem in the sector these investment objectives would be on paper. Further administrative and legal unbundling are needed in the gas sector by making Ghana Gas separate from the GNPC. Ghana Gas can then be developed as the Gas Aggregator in the Ghanaian setting. This ownership unbundling should remain in state hands but it should allow for more transparency and monitoring of such state owned organisations.

The law should focus on credit financing and the relationship in the gas to power value chain to ensure financial discipline. The regulation of Ghana Gas

Company for example requires that the offtaker Volta River Authority (VRA) should back all gas taken up with a letter of credit from a first class bank. However, no bank is prepared to provide or take up such a contingent exposure on its balance sheet. The research therefore recommends the adoption of the Chinese approach to establishing investment bodies for power financing in Ghana. The benefit from these well -established investment bodies is that they will ensure that funds collected under the energy levy tax law are not diverted by the Ministry of Finance. Currently, there is no institution to challenge the Ministry of Finance when such funds are diverted to other sectors. There is also the need for long term capital. One source should be from pension funds. Part of the Social Security and National Insurance Trust (SSNIT) pension funds should be directed into hydro and renewable projects. The financial advisory support will come from these investment bodies as experienced in China in their electricity sector reform process. Given the return on equity expected by current investors into the Ghanaian power sector, it is appropriate to internalise these returns or reduce them to achieve a better economic welfare.

In the area of project financing, the research points out that there is the need to have energy financing institutions in Ghana that mobilise resources towards the power sector development especially where the main means of transport is currently by road and possibly the rail in the next 10 to 20 years which will depend on the availability of electricity. Bankability of projects will require that the regulated segment in relation to revenue recovery for all investment into the power sector is institutionalised from the distribution point and not from the transmission point in the short to long term.

The positive side of the insolvent electricity sector is that it provides a signal about the potential size of the energy bond market if it is developed following from a sanitised electricity power value chain. The research draws policy makers attention to the fact that there is no alternative exit strategy for investors in the Ghanaian energy sector because the Ghanaian capital market has not been integrated in the government's efforts to encourage investments into the electricity sector. The development of the stock market segment which currently does not exist for electricity firms is critical as a springboard for continuous evaluation of the power sector performance and its value addition. The added effect will be the attraction of foreign capital into the sector and the effect of BITs and other international investment treaties that also serve as a controlling tool to discipline the government's attitude to the electricity sector management from the challenge that can emanate from creeping and full expropriation if there should be a failure of such investments due to state-owned institutions failing to play their critical role in the electricity value chain. The current suggestion to introduce power bonds in the Ghanaian financial environment will defer government liability and allow the government to focus on micro and macroeconomic environment management in the short term. For example because most IPPs are quoted in dollars, while the tariffs are in the local currency, the cedi, the rapid deterioration in the cedi would definitely create revenue risk. Economic stability therefore contributes partly to the attraction of investments into the energy or power sector.

The effectiveness of these measures requires that there are regulatory rearrangements within the current regulatory design or architecture. The aim is to ensure that the potential systemic risks posed by guaranteeing energy sector debts and projects locally are controlled to deepen the degree of bankability of potential power sector projects.

Finally, there is the need to revise the fiscal incentives currently given to investors. The research suggests that incentives should be shifted from profit-based to cost-based incentives. This is critical to eliminate the redundancies in the current incentives regime and create the tendency to catalyse investments in the hugely untapped renewable energy sources. Again the use of sovereign guarantees needs to be well-grounded by laws and regulations that define specific areas in the energy financing process in relation to project size, sunset clauses, completion risks, economic losses or liquidated damages and project performance.

9.6.0 LIMITATIONS AND CHALLENGES OF THE STUDY

The major limitation of the study is the relatively small number of observations, which restricted the extent to which the analysis could be done. Another challenge had been the availability and integrity of data as the production and other cost data were not easily accessible and some related economic data had to be validated from multiple sources. Such challenges required a continuous review of accounting data presented and used in this research.

The number of power plants that could meet the minimum qualifying criteria defined as any producer for 10 years with a fully audited financial statement also reduced the number of sample producers available for the research. Because all the participating firms are not on the Ghanaian stock market, the compromise between the limitations of manual collection and the need to have adequate data for the panel data analysis made it extremely labour-intensive. This also affected the number of observations for the panel study and hence the degrees of freedom for any complex estimations.

It would have been helpful to test directly the interaction effect between the power sector variables and the regulatory indicator variables but this would increase the number of regressors, reducing the degrees of freedom of the model and the power of any inference tests.

Again the study does not take into account the possible impact of other sources of power generation like biomass, solar and wind which are emerging as major sources of electricity in some areas of Ghana and also including some new IPPs. This situation has put a severe limit on the interpretation of the research findings, such as those relating to sustainability and financial effects due to the paucity of interlocking information between the formal power generation sector and the sizeable private and informal sectors in Ghana.

9.7.0 SUGGESTIONS FOR FUTURE RESEARCH

Electricity security of supply is an emerging field in energy security and therefore there are potential prospects for future research. The research followed largely an exploratory path, but did retain a focus on central issues relating to the regulatory structures and firm –level risk management measures to protect their investments in Ghana. There are issues that arose during the research that were outside the scope of the research and could not be explored within it. However, these issues open up some opportunities for future work.

The first recommendation for research is based on some of the limitations above. Future research can cover the entire power sector in Ghana including the informal sector. Again the research could be structured to take into account the security of supply in the West African sub –region given the increasing discovery of gas in the sub-region and the West African power pool.

Another area for future research is how the West African capital markets will incorporate the energy sector into its structure to sustain investments. This will have implications for financial services sector laws and regulations because of the long term nature of financing.

Future research can look into the various regulatory rearrangements suggested in this research including the suggestion for the introduction of security options, new laws on power distribution, credit laws and the marketing of government bonds and energy sector assets owned by the government.

Furthermore, future research into the effects of a fully integrated green power driven sector and adoption of time of use tariffs in developing countries like Ghana would be important due to the abundance of renewable energy sources. Finally, future research into the role of capital market development and the role of electricity project financing will be relevant in liquidity constrained regions such as the Sub-Saharan African region. This is because the electricity sector financing can be the linchpin for the rapid development of the Ghanaian and possibly the West African or regional capital markets.

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APPENDICES

Appendix 5.1: Sampling Procedure and Sample Size

Procedure Number	**Process or Activity**	**Outcomes**
1.	This table outlines the sample selection criteria and the number of power generation sources considered in this study. The data for sample generators, country and industry level activities are sourced from the Energy Commission report on the energy sector published annually from 2007 to 2016. The annual report on the Ghanaian energy sector by the Energy Ministry; Development Finance Reports on energy sectors of countries in Sub-Sahara Africa.	
2.	Initial Sample (list sources of electricity supply in Ghana) from Energy Commission, Volta River Authority (VRA) sources for the study period from 2007 to 2016	12
3.	Exclude producers with insufficient data on the generation and classification of ownership of power generated excluding rented plants that are outside VRA purchases or on a sustained contractual basis. Therefore Bui, VRA solar, BXC Company for again solar are excluded from the main regression.	4
4	Sample after this step	8
5.	Include direct exporter of power into Ghana as a generator. Therefore, CIPRAL from Cote d'Ivoire is included in the sample.	1
6.	Final Sample	9

Appendix 5.2

Diagnostic Analyses of OLS and Panel Data Assumptions (Annex to Chapter 7)

Table A presents OLS regression of the first model where the linear association of electricity security of supply (ESoS) with power market firm-level risk management and regulatory variables are accounted for. The security of electricity supply (SoES) and electricity security of supply are used interchangeably.

The first Pooled OLS Model		
OLS on ESoS		
Variable	**OLS 1**	
	Coefficient	**P(values)**
Regulation	53.27	0.883
Financial Efficiency(tariffs)	-861.82`	0.580
Size	907.95***	0.000
Sustainability	121.06***	0.001
Ownership	808.26*	0.067
Constant	-17048.12**	0.018
Number of Observations	90	
F(5, 84)	11.70	
Prob > F	0.0000	
R-squared (R^2)	0.3971	
Adjusted R-squared	0.3612	
Legend : * p< 0.1; ** p< 0.05; *** p< 0.10		
Note: As indicated in the legend: * indicates significance at 10% level; ** indicates significance at 5% level; *** indicates significance at I% level.		

The F tests of the OLS regression model indicate that the fit of the model as a whole is good, which shows that there might not be a problem of specification. However, from the very low R-squared statistic is 39% and the adjusted R-squared is 36%. They indicate that a low part of the variation in ESoS is explained by the included independent variables in the model. This can be the first signal showing that OLS estimators might not be efficient and OLS cannot be the appropriate estimation method. Hence, in order to choose the appropriate estimation methods, we first make diagnostic analyses of the OLS assumptions so as to check whether the normally and independently distributed (NID) assumptions of OLS are met.

Normality of residuals

An assumption of the regression model (OLS) that impact the validity of all tests (p, t and F) is that residuals behave normal. Residuals (here indicated by the letter 'e') are the difference between the observed values(Y) and the predicted values (Yhat): e=Y- Yhat.

If residuals do not follow a 'normal' pattern then we should check for omitted variables, model specification, linearity, functional forms. In sum, we may need to reassess our model/theory. Normality is a problem when dealing with small samples.

A non-graphical test is the Shapiro-Wilk test for normality. It tests the hypothesis that the distribution is normal, in this case the null hypothesis is that the distribution of the residuals is normal.

The *numerical tests for normality* of the residuals by the Shapiro- Wilk W test for the null hypotheses of normal distribution yields the p-values is 0.20 and therefore we failed to reject the null hypotheses at 90%, 95% and 99%. We conclude that the residuals are normally distributed. This indicates that we have to accept the null hypothesis, i.e., the normality of residuals.

Table B: Test for Normality of Data

Shapiro-Wilk W test for normal data for Model 1 Swilk e					
Variable	Observations	W	V	Z	Prob>z
e	90	0.98066	1.463	0.839	0.20079
Shapiro-Wilk W test for normal data for Model 1 Swilk r					
Variable	Observations	W	V	Z	Prob>z
r	90	0.98066	1.463	0.839	0.20079
Source: STATA 12					

Homoskedasticity of Residuals

A non-graphical way to detect heteroskedasticity is the Breusch-Pagan/ Cook-Weisberg test. It tests the null hypothesis that the error covariances are all equal versus the alternative that the error variances are a multiplicative function of one or more variables.

For example, in the default hattest command shown below, the alternative hypothesis stated that the error variances increase (or decrease) as the predicted value of Y increases. That means that the bigger the predicted value of Y, the bigger the covariance is. A large chi-square would indicate that heteroskedasticity was present. In this example, the chi-square value was small, indicating heteroskedasticity was probably not a problem (at least that if it was a problem, it was not a multiplicative function of the predicted value). In this test, if the chi-square obtained exceeds the critical chi-square value at the chosen level of significance, the conclusion is that there is heteroskedasticity. The chi-square is less than the critical at the chosen level of significance at 90%, 95% and 99%. This indicates that the residuals have a homogeneous variance. Hence, the numerical tests and the nature of panel data, the sounding judgment is that the residuals are homoskedastic. The implication is that if the variances were heteroskedastic, we may have the wrong estimates of the standard errors for the coefficients and therefore their t-values.

Table C: Breusch-Pagan/ Cook-Weisberg test for Heteroskedasticity

estat hettest	
Breusch-Pagan / Cook-Weisberg test for heteroskedasticity H0= Constant variance Variables: fitted value of ESoS	
Chi 2(1)	0.16
Prob > chi 2	0.6886
Source: STATA 12	

Multicollinearity

As a first step in checking for multicollinearity between the independent variables, Pearson's pair-wise correlation result is presented as in Table 6.3. It can be observed from the table that almost all of the correlations between pairs of the variables are less than 0.60, which shows that they have no problem of multicollinearity. In order to test for multicollinearity in the residuals, assessment of the variance inflation factor (VIF) is made to check for the level of multicollinearity. The VIF, which leads us to the *tolerance* level of multicollinearity, 1/VIF, of the model (*Table E)* shows a mean VIF of 1.53 (Models 1). A VIF greater than (>) 10 or 1/ VIF less than 0.10 indicates a multicollinearity problem. Since the model has a VIF that is less than 10 and (1/ 1.53) is 0.65 and is far greater than 0.10, and it is more than 0.10. This shows that there is no multicollinearity problem.

Table D: Variance inflation factor, VIF, and tolerance using STATA12

Estat vif		
Model 1 and 2		
Variables	**VIF**	**1/VIF**
Regulation	2.09	0.478621
Financial Efficiency	2.03	0.493491
Size	1.29	0.776024
Sustainability	1.23	0.814526
Ownership	1.04	0.965855
Mean VIF	1.53	
Source: STATA 12		

Independence of errors

In the panel data values that come from the same variable overtime and when there can be some form of homogeneity among the elements in a group, it is more likely that the errors of different observations can be correlated (the autocorrelation of errors) with the adjacent time or group than those separated in time or in heterogeneity.

The Breusch-Godfrey LM test for autocorrelation is used due to its robustness. Table E illustrates the results of the test.

Table E: Breusch – Godfrey LM Test for Autocorrelation

Lags(p)	**Chi2**	**df**	**Prob. chi 2**
1	20.697	1	0.0000
5	22.470	5	0.0004
Source: STATA 12			

The table shows that the probability a chi-square value as much as 20.697 or greater is zero. To achieve the chi –square value of 22.470, must be extremely small or the actual p-value is almost zero. The result is that at least one of the five autocorrelations must be non-zero.

This implies that we need to find out if the autocorrelation is pure autocorrelation and not as a result of the misspecification of the model. Again if it is pure autocorrelation one can use the appropriate transformation of the original model so that in the transformed model, we do not have the problem of (pure) autocorrelation. Gujirati and Porter (2009), Battaglia and Gallo (2015), show that in the case of autocorrelation, one can make use of the generalised least squares (GLS) method.

Model specification test

The last diagnostic test on the model is to ensure whether the appropriate variables are included and/ or omitted from the model. This is important since, first, if one or more of the relevant variables are omitted, the common variance they share with the rest in the model may be wrongly attributed to the included variables, and the error term is inflated, and second, if the irrelevant variables are included, the common variance they share with the rest in the model would wrongly be attributed to the irrelevant. The model specification problems or errors would affect the estimated regression coefficients substantially, and it is difficult to know the exact influence contributed by a predictor variable on the dependent variable.

One of the methods of detecting specification errors is by using the predicted values and the square of the predicted values and regress them on the dependent variable as predictors and check their significance.

The premise is that when the regression model is properly specified, there should not be any additional predictor variables that are significant. The post estimation *linktest* (Table F, Panel A) is therefore used to check whether we need more variables in our model by running a new regression with the observed Y (ESoS) and Y hat –squared as independent variables. The post estimation *linktest* (Table F, Panel A) shows that the predicted value variables (**_hat**) is significant, thus indicating that there is no specification error.

Additionally, the square of the predicted values (_**hatsq**), which is expected to be insignificant (0.127) for the correct specification, have no explanatory power. Hence, the linktest in which the expected significance of _**hat** is significant and _**hatsq** is insignificant reveals that our model is specified correctly, and there is no omitted variable. The thing to look for here is the significance of _hat sq. The null hypothesis is that there is no specification error. If the p-value of _hatsq is not significant then we fail to reject the null and conclude that our model is correctly specified.

Table F: Panel A: Linktest

Linktest Model 1						
Source	**SS**	**df**	**MS**	**Number of obs. = 90**		
Model **Residual**	**180051182** **255765567**	**2** **87**	**90025590.8** **2939834.1**	**F(5, 84) = 30.62** **Prob > F =0.0000**		
Total	**435816748**	**89**	**4896817.4**	**R-squared =0.4143** **Adj. R-squared = 0.3996** **Root MSE = 1714.6**		
ESoS	**Coef.**	**Std. Err.**	**t**	**P> t**	**95% Conf. Interval**	
_hat	**1.951298**	**0.6305342**	**3.09**	**0.003**	**0.6980427**	**3.204553**
_hatsq	**-0.0001212**	**0.0000786**	**-1.54**	**0.127**	**-0.0002773**	**0.000035**
_cons	**-1613.216**	**1155.887**	**-1.40**	**0.166**	**-3910.66**	**684.2344**
Source: STATA 12						

Table F: Panel B: Ramsey Ovtest

estat ovtest

Ramsey RESET test using powers of the fitted values of ESoS

H_0: **model has no omitted variables**

F(3, 81) =0.94

Prob > F=0.4241

Source: STATA 12

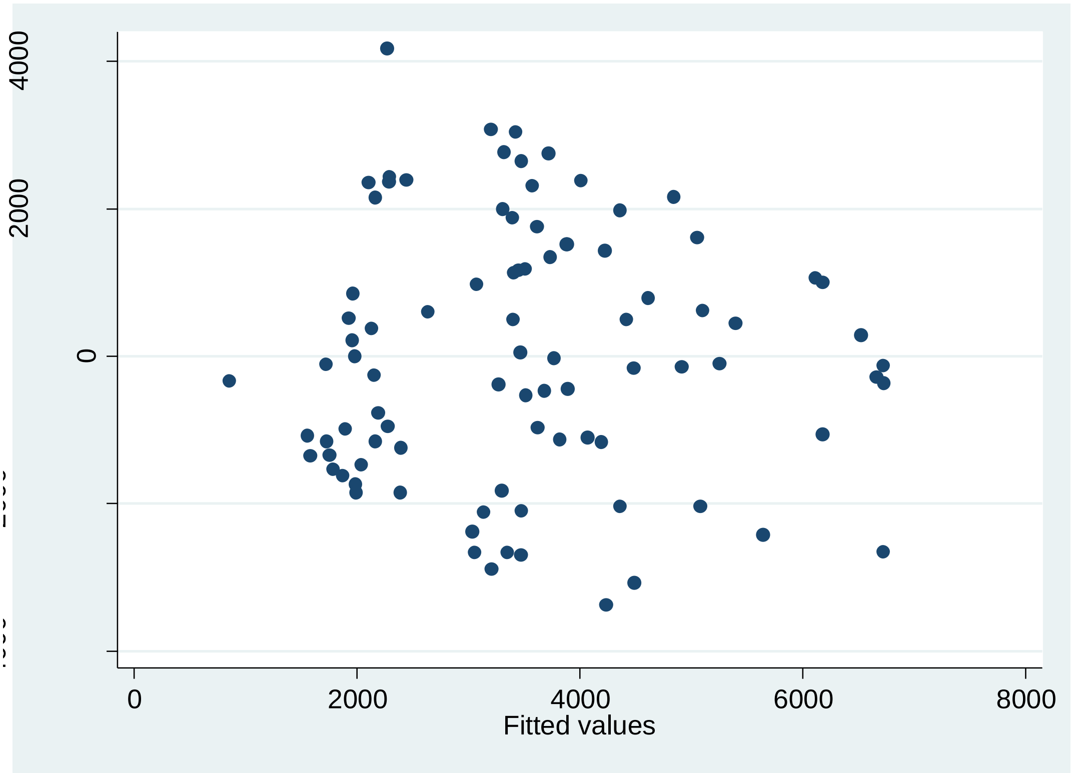
The other specification test, called the Ramsey RESET test (Table F: Panel B), is another test for omitted variables. It creates new variables based on the predictors and refits the model using the new variables and tests if any of them would be significant. In STATA, the **ovtest** command (a postestimation command) executes this test.

Testing for an omitted variable bias is important for our model since it is related to the assumption that the error term and the independent variables in the model are not correlated, i.e. (E$(e|X) = 0$). The null hypothesis is that the model does not have omitted variables bias, the p-value is higher than the usual thresholds of 0.01, 0.05 and 0.10 (90%, 95 % and 99% significance), so we fail to reject the null and conclude that we do not need more variables.
The test, as it can be seen below, shows that the F-test is not significant to reject the null hypothesis of no omitted variables. This indicates that there is no specification error, thus, omitted variables. This is what the R-squared statistics suggest. Adding more predictors into the model will not improve the R-squared.

Tests for Linearity

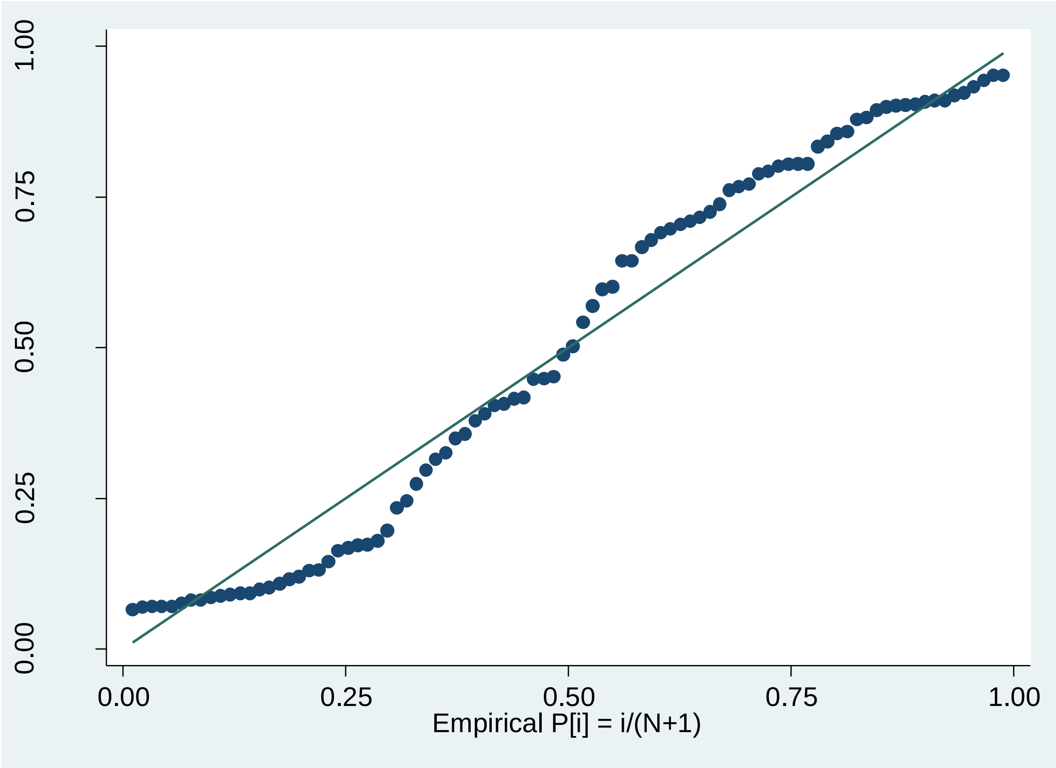
Here it must be noted that we have a multiple OLS regression where several independent variables are involved. In a panel data, the linear relationship between the dependent and each of the independent variables; and between the dependent variable and the independent variables collectively were carried out. Hence, the check for linear relationship between the dependent variable and the independent variables cannot be straightforward. This check on individual independent variables shows that many of the variables show no clear departure from linearity. The plotting the standardized residuals against each predictor variable in the model to check for linearity between the predictors and the response variable show that they show some patterns of linearity as shown in Figures A and B. Figure C shows the partial regression plots (or added-variable plots) which plot the relationship between the ESoS and an independent variable when the effect of other variables are removed and it is also good for diagnosing outliers. Figure D (i- vi) show the twoway scatter graphs with graphical assessment of linearity of the ESoS in predictors, with line and lowess fits. The lowess lines for size, financial efficiency, regulation (substance and governance), and ownership look reasonably linear. That of the sustainability also looks reasonably linear, albeit being pretty flat. The minor splitting gap at the beginning or at the end of the sustainability line is not a big problem since there might be some influential observations that cause divergence. So, we conclude that the linearity assumption is fulfilled. However, it is difficult to establish the linearity by using plots and there is also a room for non-linearity.

Figure A: Residuals –versus – fitted plots



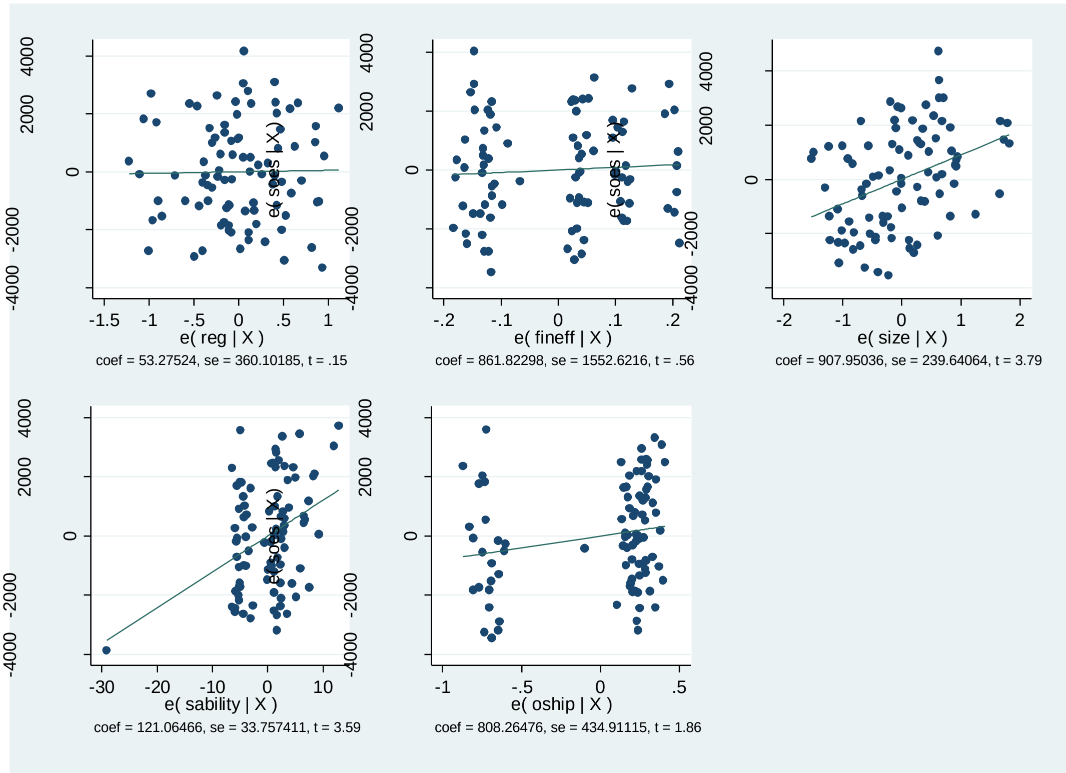
Source: Stata 12

Figure B: ESoS OR SOES: Residuals (Close to normality)



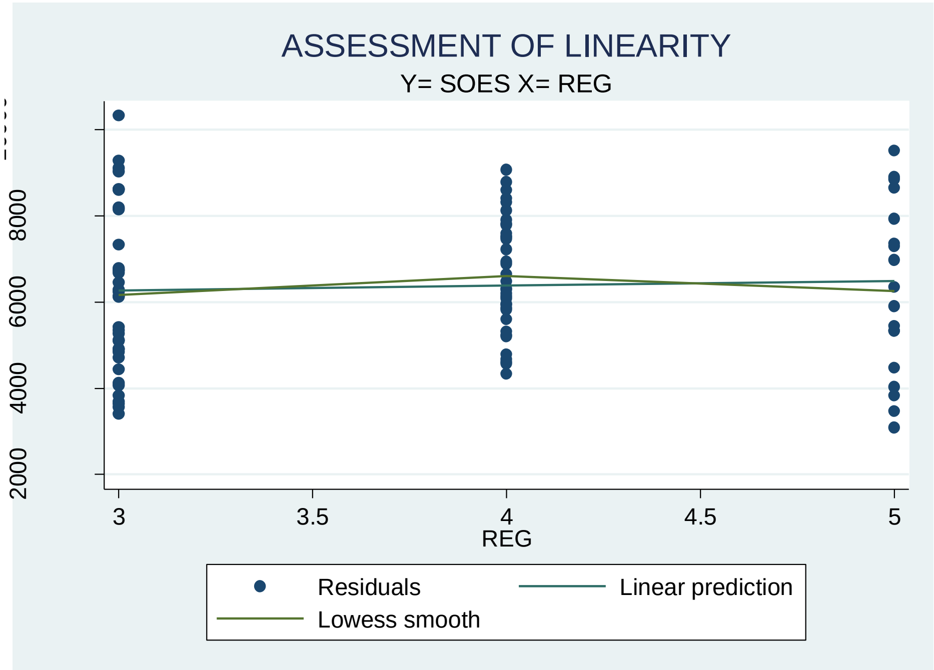
Source: Stata 12

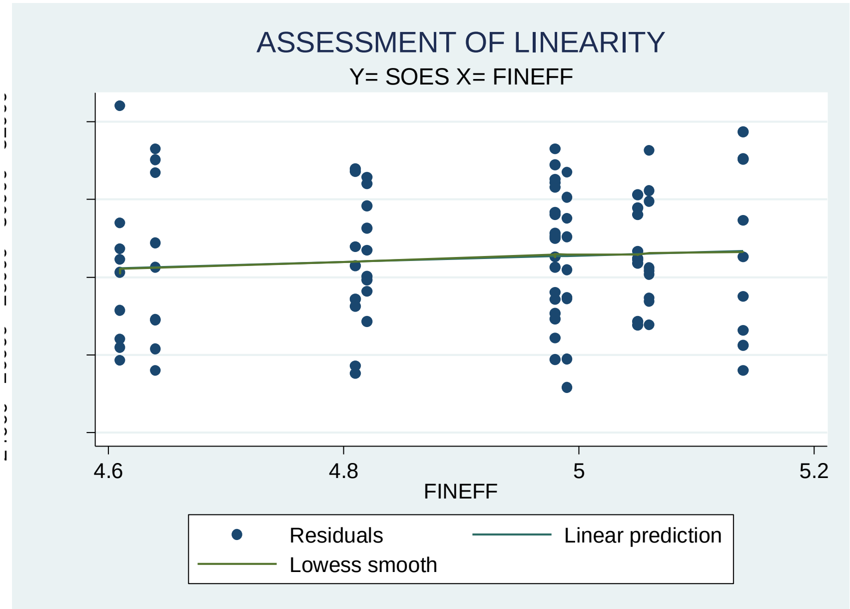
Figure C: Partial Regression Plot (avplots)

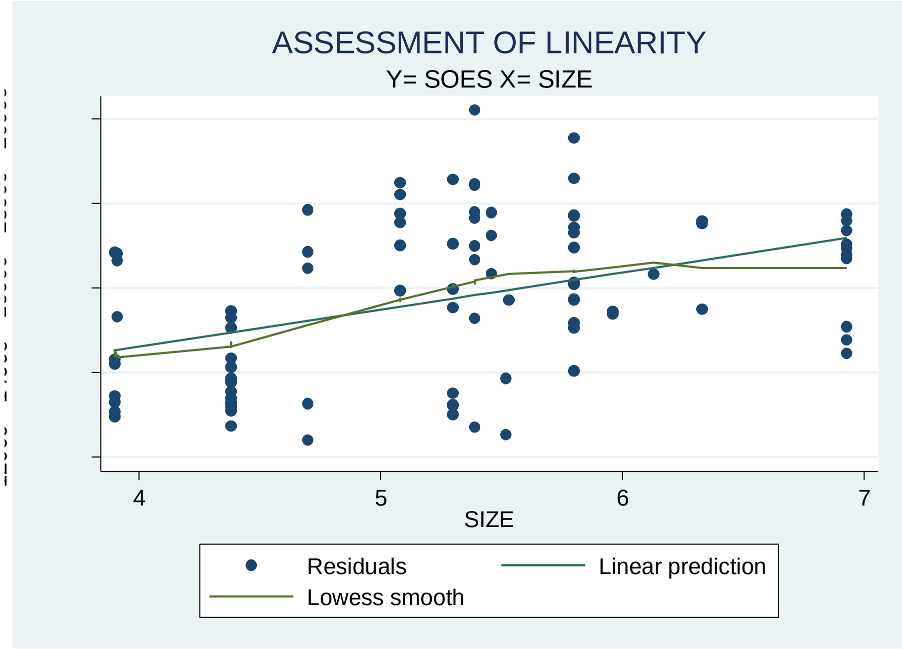


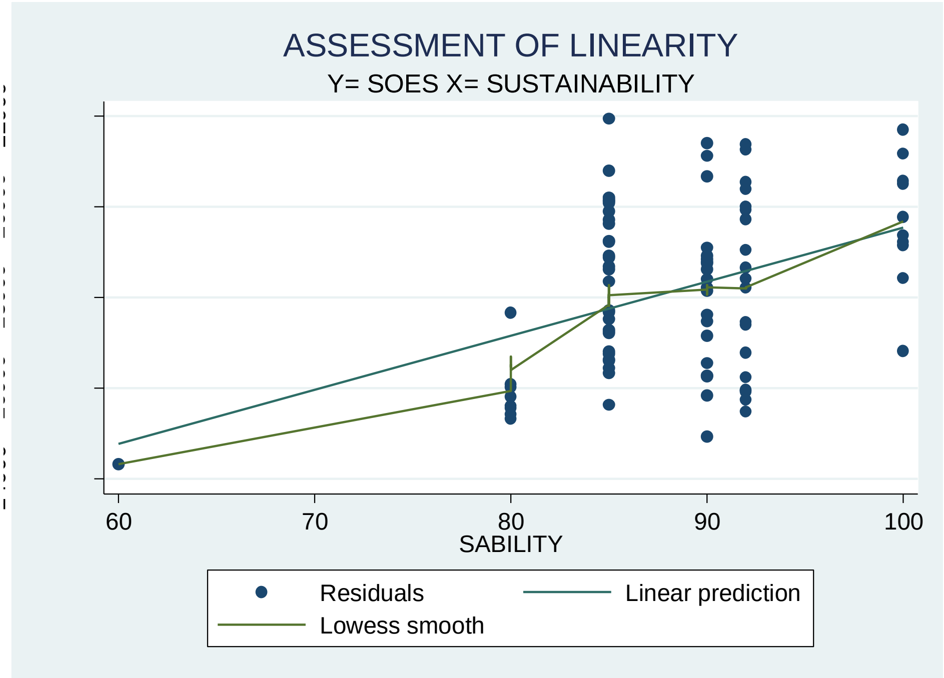
Source: Stata 12

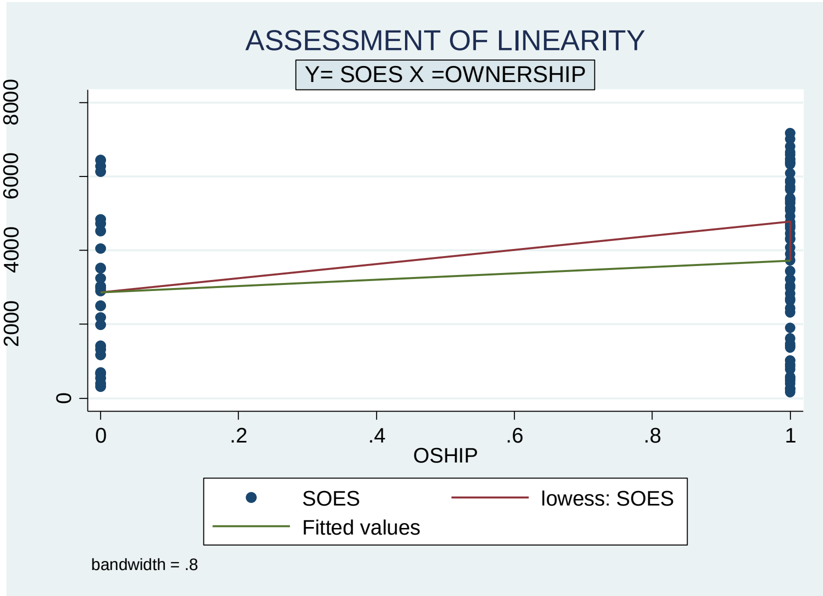
Figure D(i-iv) :Assessment of Linearity






ASSESSMENT OF LINEARITY
Y= SOES X= SIZE
4
5
6
7
SIZE
Residuals
Linear prediction
Lowess smooth


ASSESSMENT OF LINEARITY
Y= SOES X= SUSTAINABILITY
60
70
80
90
100
SABILITY
Residuals
Linear prediction
Lowess smooth



Source: STATA 12

APPENDIX 5.3: PANEL DATA DIAGNOSTICS AND PANEL RESULTS

To test for use of either the fixed effects or random effects model is appropriate, and against the violations to OLS conditions discussed in Appendix 5.2, the Breusch – Pagan and Hausman tests are presented in the Tables G and H below.

Breusch and Pagan Lagrangian multiplier test for random effects

ESoS [idno, t] =xb +u[idno] + e[idno, t]

Table G: Estimated Results: Breusch - Pagan Tests

		Variable	**Sd=sqrt(Var)**
	ESoS	4896817	2212.875
	e	2125581	1457.937
	u	1456773	1206.968
Tests	Var(u) =0		
	Chibar 2(01)	27.10	
	Prob > chibar	0.0000	
Source: STATA 12			

The results from Table G show that fixed effects and random effects estimation techniques are preferred to pooled OLS estimation method. The choice between fixed effects and random effects is determined by using the Hausman test as shown in Table H. The results show that the random effects estimation is preferred to the fixed effects estimation because there are some panel effects which can be efficiently dealt with using the GLS random effects and the GMM estimation techniques.

TABLE H: Hausman Test (Fixed effects or fe)

Coefficients				
Variables	**(b)** **fe**	**(B)**	**(b-B)** **Difference**	**Sqrt(diag(v_b-** **V _B)) S.E.**
Reg	277.7659	148.3027	129.4631	118.8799
Fineff	1110.678	1038.909	71.76851	44.50829
Size	252.8386	645.1961	-392.3575	388.6191
Sability	102.7693	113.8679	-11.09857	21.98056
Oship	-662.5438	-150.5893	-511.9544	364.8632
. b = consistent under Ho and Ha; obtained from xtreg B= inconsistent under Ha, efficient under Ho; obtained from xtreg Test: Ho: difference in coefficient not systemic Chi2 (6) = (b- B) ‘ [(V_b – V_B^(-1)] (b- B) = 3.46 Prob > chi2= 0.6290				
Source: STATA 12				

TABLE I: ESTIMATION RESULTS AND FORECASTING PERFORMANCE

Pooled OLS						
Regress ESoS, reg fineff size sability oship						
Source	SS	df	MS		Number of Obs =90	
Model	173060763	5	34612152.50		F(5, 84) =11.07	
Residual	262755986	84	3128047.45		Prob > F = 0. 0000	
Total	435816748	90	4896817.40		R-squared = 0.3971	
					Adj R-squared =0.3612	
					Root MSE = 1768.6	
ESoS	Coef.	Std. Err	t	p>|t|	[95% Conf. Interval]	
Reg	53. 275	360.101	0.15	0.883	-662.826	769.377
Fineff	861.823	1552.622	0.56	0.580	-2225.735	3949.381
Size	907.950	239.640	3.79	0.000	431.398	1384.502
Sability	121.064	33.757	3.59	0.001	53.934	188.195
Oship	808.264	434.911	1.86	0.067	-56.603	1673.133
_cons	-170485.12	7092.16	-2.40	0.018	-31151.66	-2944.581
Forecasting Performance: Coefficient of Variation of the Root Mean Square (CVRMSE) Estimate: di 100* e(rmse)/ r(mean) = 18.991908						
Source: STATA 12						

Fixed Effects Model						
Xtreg ESoS, reg fineff size sability oship, fe						
Group variable : idno					Number of Obs =90	
R-sq:	within=	0.1553			Number of groups =9	
	between	0.2931			Obs per group	Min=10
						Avg=10
						Max=10
	overall	0.2303			F(5, 76) =2.79	
Corr(u_i, Xb)=0.0960					Prob > F =0.0227	
ESoS	Coef.	Std. Err	t	p>|t|	[95% Conf. Interval]	
Reg	277.765	336.389	0.83	0.412	-0.392.212	947.744
Fineff	1110.678	1292.088	0.86	0.393	-1462.738	3684.093
Size	252.838	548.780	0.46	0.646	-840.153	1345.830
Sability	102.769	47.017	2.19	0.032	9.126	196.412
Oship	-662.543	705.665	-0.94	0.351	-2067.998	742.910
_cons	-12951.62	7190.526	-1.80	0.076	-27272.79	1369,555
Sigma _u	1481.2467					
Sigma _e	1457.9374					
rho	0.50793005	(fraction of variance due to u_i)				
Forecasting Performance: Coefficient of Variation of the Root Mean Square (CVRMSE) Estimate: di 100* e(rmse)/ r(mean) = 16.6766						
Source: STATA 12						

Random Effects Model						
Xtreg ESoS, reg fineff size sability oship, re						
Random Effects GLS Regression Group variable : idno					Number of Obs =90	
R-sq:	within=	0.1430			Number of groups =9	
	Between=	0.5252			Obs per group	Min=10
						Avg=10
						Max=10
	Overall=	0.3524			Wald chi2(5)= 20.10	
Corr(u_i, X)=0 (assumed)					Prob > F =0.0012	
ESoS	Coef.	Std. Err.	z	p>$\|t\|$	[95% Conf. Interval]	
Reg	148.302	314.683	0.47	0.637	-468.465	765.071
Fineff	1038.909	1291.321	0.80	0.421	-1492.033	3569.851
Size	645.196	387.473	1.67	0.096	-114.237	1404.63
Sability	113.867	41.562	2.74	0.006	32.406	195.329
Oship	-150.589	604.018	-0.25	0.803	-1334.443	1033.265
_cons	-5.246363	6524.675	-2.38	0.017	-28329.29	-2753.053
Sigma _u	1206.968					
Sigma _e	1457.937					
rho	0.40665	(fraction of variance due to u_i)				
Forecasting Performance: Coefficient of Variation of the Root Mean Square (CVRMSE) Estimate: di 100* e(rmse)/ r(mean) = 16.667408						
Source: STATA 12						

The random effects model has a smaller coefficient of variation and therefore predicts values that are closer to the actual values.

ROBUSTNESS TESTS: GMM ESTIMATION RESULTS

Number of Moments=7						
Initial weight Matrix: Unadjusted						
GMM weight matrix: Robust				**Number of Obs = 90**		
	Coef.	**Robust Std. Errors**	**z**	**p>|z|**	**[95% Conf. Interval]**	
Constant	-16886.86	6651.221	-2.54	0.011	-29923.02	-3850.708
Reg	72.510	346.73	0.21	0.834	-607.068	752.088
Fineff	816.032	1497.26	0.55	0.586	-2118.543	3750.608
Size	908.978	204.260	4.45	0.000	508.635	1309.322
Sability	120.824	27.094	4.46	0.000	67.719	173.928
Oship	821.189	464.346	1.77	0.077	-88.913	1731.293
Instruments for equation 1: reg fineff size sability oship ctype _cons						
Estat overid						
Test of overidentifying restriction:						
Hansen's J Chi2(1) = 0.80831 (p=0.7762)						
Source: STATA 12						

GMM Estimation						
Number of parameters =6						
Number of Moments=7						
Initial weight Matrix: Unadjusted						
GMM weight matrix: HAC Bartlett 88				**Number of Obs = 90**		
	Coef.	**Robust Std. Errors**	**z**	**p>|z|**	**[95% Conf. Interval]**	
Constant	-17232.37	5627.411	-3.06	0.002	-28261.89	-6202.85
Reg	84.129	365.973	0.23	0.818	-633.165	801.424
Fineff	881.706	773.324	1.14	0.254	-633.981	2394.396
Size	897.047	284.949	3.15	0.002	338.554	1455.538
Sability	121.991	49.480	2.49	0.014	25.011	218.971
Oship	748.084	696.414	1.07	0.283	-616.862	3113.03
HAC standard errors based on Bartlett kernel with 98 lags						
Instruments for equation 1: reg fineff size sability oship ctype _cons						
Estat overid						
Test of overidentifying restriction:						
Hansen's J Chi2(1) = 0.042725 (p = 0.8362)						
Source: STATA 12						

GMM Estimation						
Number of parameters =6						
Number of Moments=7						
Initial weight Matrix: Unadjusted						
GMM weight matrix: HAC Barlett 9 (lags chosen by Newey-West)				**Number of Obs = 90**		
	Coef.	**Robust Std. Errors**	**z**	**p>$\|z\|$**	**[95% Conf. Interval]**	
Constant	-17101.59	5726.934	-2.99	0.003	-28326.17	-5877.007
Reg	81.710	369.616	0.22	0.825	-642.728	806.150
Fineff	855.198	895.943	0.95	0.340	-900.818	2611.215
Size	904.385	280.659	3.22	0.001	354.303	1454.468
Sability	121.517	44.078	2.76	0.006	35.125	207.909
Oship	793.300	614.030	1.24	0.214	-440.176	1966.777
HAC standard errors based on Bartlett kernel with 9 lags.						
Instruments for equation 1: reg fineff size sability oship ctype _cons						
Estat overid						
Test of overidentifying restriction:						
Hansen’s J Chi2(1) = 0.043122 (p=0.8355)						
Source: STATA 12						