A Complex Systems Approach to Energy Poverty in sub-Saharan Africa:

Nigeria as a Case Study

by

Chukwunonso Chidebell Emordi

A Dissertation Presented in Partial Fulfillment
of the Requirements for the Degree
Doctor of Philosophy

Approved August 2015 by the
Graduate Supervisory Committee:

Abigail York, Chair
Martin Pasqualetti
Aaron Golub

ARIZONA STATE UNIVERSITY

December 2015

ABSTRACT

Energy poverty is pervasive in sub-Saharan Africa. Nigeria, located in sub-Saharan West Africa, is the world's seventh largest oil exporting country and is a resource-rich nation. It however experiences the same levels of energy poverty as most of its neighboring countries. Attributing this paradox only to corruption or the "Dutch Disease", where one sector booms at the expense of other sectors of the economy, is simplistic and enervates attempts at reform. In addition, data on energy consumption is aggregated at the national level via estimates, disaggregated data is virtually non-existent. Finally, the wave of decentralization of vertically integrated national utilities sweeping the developing world has caught on in sub-Saharan Africa. However, little is known of the economic and social implications of these transitions within the unique socio-technical system of the region's electricity sector, especially as it applies to energy poverty. This dissertation proposes a complex systems approach to measuring and mitigating energy poverty in Nigeria due to its multi-dimensional nature. This is done via a three-fold approach: the first section of the study delves into causation by examining the governance institutions that create and perpetuate energy poverty; the next section proposes a context-specific minimum energy poverty line based on field data collected on energy consumption; and the paper concludes with an indicator-based transition management framework encompassing institutional, economic, social, and environmental themes of sustainable transition within the electricity sector. This work contributes to intellectual discourse on systems-based mitigation strategies for energy poverty that are widely applicable within the sub-Saharan region, as well as adds to the knowledge-base of decision-support tools for addressing energy poverty in its complexity.

DEDICATION

This work is the culmination of five years of study and could not have been possible without the support of family and friends. To my mother Ife' Chidebell, I do not have the words to thank you for your nurturing support, editing help, and encouragement when it seemed that this journey would never end. You are the most amazing mother and grandmother and if I am able to have half the determination and strength you have had I would consider myself a success. To my siblings Dr. Bonte Gbemudu and Professor Caleb Chidebell, thank you for your listening ear, your emotional, financial, and other support. To my husband Fel, my constant cheerleader who believes the world is my oyster, thank you. To my little princess Chukwunonso Chloe Emordi, you are the light of my life. Your smile makes every day a blessing, I cannot imagine my life without you in it.

To Dr. Daniel Nzengya, all those brain storming sessions paid off, I look forward to collaborations in the future. To all my friends, Lauren Blaine, Kelechi Onwuchekwa, Sherine Osunlalu, Dr. Herve' Ngangia, your love and encouragement are most appreciated.

ACKNOWLEDGMENTS

This dissertation would not have been possible without the support of many people. I would like to express my sincere appreciation to my committee chair, Professor Abigail York for her investment in me and continuous constructive feedback both on my writing and my academic career. I thank committee members Professors Aaron Golub and Martin Pasqualetti for their encouragement and direction. I owe Professor C.B.N. Ogbogbo, my committee member from University of Ibadan, Nigeria, thanks for his invaluable input as an energy historian. My gratitude also goes to Professor Adenikinju, director of the Center for Policy, Energy Economics, and Law (CPEEL) at the University of Ibadan for his invaluable insights in, and access to, the Nigerian energy sector as well as logistic support for research. To my research assistant Nafisat Shittu, University of Ibadan class of 2013, I appreciate your friendship, determination, hard work, and industriousness. Without you field research would have been an uphill task, thank you.

To Professor Rimjhim Aggrawal who encouraged my interest in disparity of mental models between the global North and South, I will forever be in your debt. To Professor Arnim Wiek, you piqued my interest in holistic systems thinking and causation and changed the way I looked at engineering problems, thank you. To Dean Boone, always ready with to be a referee and making my academic journey easier at ASU, thank you. To Professor May Bogess in statistical consulting, thank you for streamlining data processing of my results and teaching me STATA. To Professor Matthew Frasier, I learned so much from you as your TA. Your teaching style is one that I continuously emulate, thank you for modeling what professionalism in teaching looks like. Finally, this journey would not have been what it was without the constant encouragement, support, and superb teaching and editing skills of Professor Kathy Kyle who I consider a part of my family. Thank you so much.

I thank Elsevier Press for permission to include Chapter 3 of my dissertation, which was originally published in Energy Research for Social Sciences Journal. Appreciation goes to the National Security Education Program Boren for funding my research.

TABLE OF CONTENTS

CHAPTER Page

CHAPTER Page

LIST OF TABLES

Table Page

LIST OF FIGURES

Figure Page

CHAPTER 1

INTRODUCTION

1. Introduction

The link between poverty and energy services is a crucial one: it is necessary for the delivery and provision of basic needs - food, clean water, shelter, health and educational services (WEC, 1999; Toman and Lemelkova, 2003). Often, poverty alleviation programs do not recognize this link even though energy consumption is an indicator of both social and development progress (Alam et al., 1997; Barett, 2000). Case in point, the United Nations millennium declaration which benchmarks a roadmap to reduce poverty and eliminate extreme poverty via the millennium development goals (MDGs). The eight MDGs are to eradicate extreme poverty and hunger, achieve universal primary education, promote gender equality and empower women, reduce child mortality, improve maternal health, combat HIV/AIDS and other diseases, ensure environmental sustainability, and to develop a global partnership for development (UNDP, 2003). These goals are tied to the foremost goal of eradicating extreme poverty by providing basic needs, however provision of energy services is not recognized as one of these basic needs.

Sub-Saharan Africa which is the poorest region in the world with 47 percent of its population living on $1.25 or less per day, is the largest recipient of multiple foreign aid programs directed at poverty alleviation (WB, 2011; UNDP, 2015). These programs primarily focus on sustainable development, climate and disaster resilience, and gender equity in the form of micro loans for small-scale businesses and agricultural ventures.

Across sub-Saharan Africa (SSA), these aid programs come with donor-imposed conditions and a reporting system with benchmarks that are not reflective of actual incremental improvements in local capacity (human, social, financial, environmental) but rather metrics that correlate to the amount of aid invested and number of projects completed (Handley et al., 2008).

In Nigeria however, almost all of the poverty alleviation programs have been initiated by the national government rather than foreign aid. The most notable of these are Operation Feed the Nation (1972), Family Support Program (1993), and most recently the National Poverty Eradication Program (2001). It is in programs like these that the direct link between energy services and poverty alleviation are most visible.

The most recent of these programs, the National Poverty Eradication Program (NAPEP) was created for the "eradication of absolute poverty in Nigeria" (FRN, 2001). Its activities were four-fold: (i) youth empowerment through enterprise promotion, (ii) rural infrastructure development, (iii) natural resource development and conservation, and (iv) social welfare service providing micro loans and other infrastructure establishment and maintenance. The funds to run the program were allocated to the 36 Nigerian states and their local governments through local NAPEP offices. The rationale is based on the fact that home-grown businesses constitute the majority of all registered businesses (80%) and that encouraging entrepreneurship would eradicate extreme poverty (Ogechukwu, 2011; FRN, 2001). Research however shows that most of the micro loans used to start small-scale businesses were not repaid because the exorbitant costs of energy services were not anticipated, effectively making the businesses non-profitable (Kasali & Sowunmi, 2013). Thus poverty alleviation programs that do not explicitly address energy needs are doomed to failure because of the direct link between energy and economic productivity.

It is important to note that energy poverty is disparate from fuel poverty. The former is primarily used in the developing-world context to describe lack of access to adequate facilities for cooking, lighting, and electrical appliances. It is driven by low levels of electrification, poor or inadequate infrastructure and non-functional institutions, resulting in low economic development and other social issues. The latter is used in the developed-world context and refers to inadequate heating in the home due to high or rising energy costs in relation to low household incomes resulting in impacts to short- and long-term mental and physical health impacts (Bouzarovski & Petrova, 2015). This study focuses on energy poverty due to low levels of electrification in sub-Saharan Africa.

As aforementioned, energy consumption is an indicator of development progress. By this metric, Sub-Saharan Africa is the least developed and most energy-poor region in the world (fig 1.1).

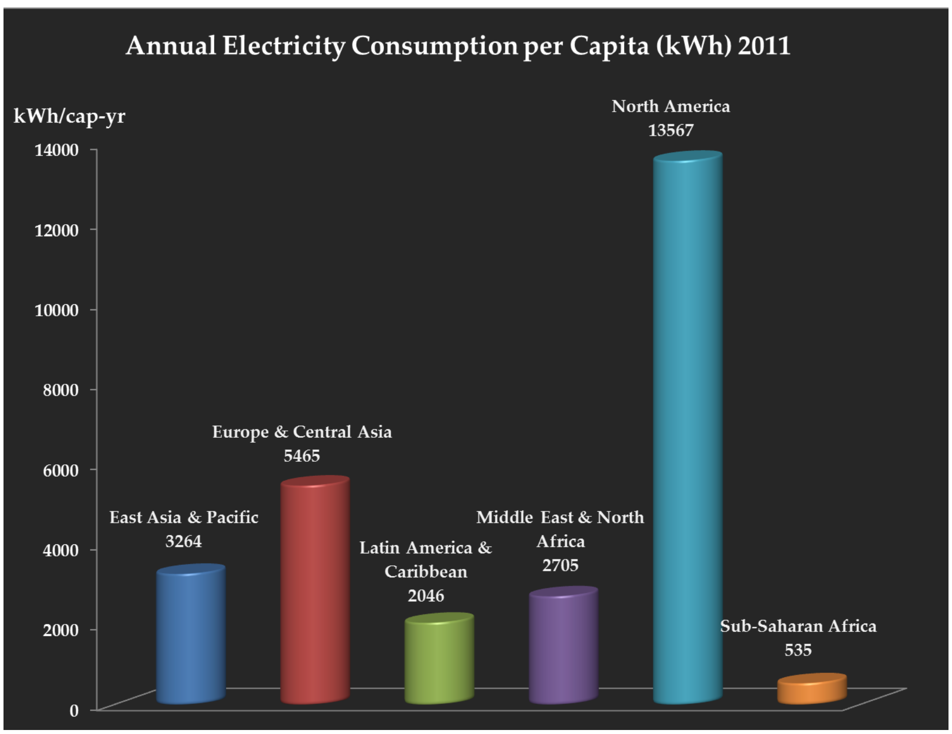

Figure 1.1 Electric energy consumption per capita 2010. *Source:* World Bank.

This study examines energy poverty in urban locations in SSA countries with Nigeria as a case study. Cities in SSA have the highest growth rate in the world, averaging five percent annually (Pieterse, 2010). This is due to post-independence macro-economic policies pursued by African governments in the 1960s and 1970s that encouraged the establishment of large-scale capital-intensive industries in cities. Agricultural policies and exchange rates kept food prices down, creating poverty in the rural areas which depend on agriculture for income-generation and thus incentivized migration to the urban areas (Hove et al., 2013). Rural-urban migration in SSA countries is the single most important cause of the urban population growth rate and accounts for 60 to 70 percent of the urban population (Todaro, 2000). Historically urbanization is often accompanied by industrialization and rapid and sustained economic growth (Hove et al., 2013). However in SSA, rapid urbanization occurred during a period of stagnating and declining economic growth and created a scenario with increasing urban poverty and stress on the limited economic, social, and environmental resources in the cities. With rural-urban migrations expected to increase within the region over the next 30 years (Cohen, 2006), the issue of energy poverty in cities in SSA is important in the general discourse on poverty and sustainable development.

Much like the rest of SSA, Nigeria has strong intra-regional ties within SSA because present-day SSA nations were carved out of prior empires and kingdoms. It has experienced similar challenges with development, governance institutions, and ethnic heterogeneity resulting in civil wars. It also the location of the largest megacity in Africa, Lagos, with its attendant challenges with compromised infrastructure, supply, and access to energy services, and as such is appropriate for studying energy poverty in a sub-Saharan African city.

This study is in three parts: it first describes the current state of energy poverty and then explores causation by expounding on the history of its governance institutions. Next, drawing from field-based research, a minimum energy poverty line is proposed and electricity needs are modeled for the next twenty years based on population growth projections as well as similarities in diet and lifestyle. This portion of the study has been published in a peer-reviewed journal. Finally an indicator-based transition management strategy for transition from an energy-poor to an energy-secure economy is proposed.

1.1 Problem Statement.

Much like most of sub-Saharan Africa, Nigeria was a colony of Europe, formed after the amalgamation of 1914. It is a resource-extractive state with a history of political instability characterized by a series of military dictatorships and coups d'état over 25 years of its 50 year history as a nation (Okoh, 2003). These political dynamics created a norm in which the leadership of the country effectively became a revolving door, with multiple policy shifts, new policies created by each new military regime, conflicted regulators due to rent-seeking behavior, as well as inadequate sanctions due to the proliferation of policies. These factors have impeded critical reforms in the energy sector (Amobi, 2006). Current initiatives to deregulate the energy sector have opened doors for public-private partnerships in addressing energy needs in the form of electrification and cooking fuels, not just within Nigeria, but also to supply power to neighboring energy-poor countries (Iwayemi, 2008). However research shows that there are institutional hurdles that inhibit the success of any such initiatives. Energy poverty is a complex subject encompassing issues related to energy supply, access, provision, acceptability, and most importantly, governance. The first part of the study will assess the state of energy poverty in Nigeria today, examine legislation related to the electricity sector from its inception, and show how energy governance over time has created energy poverty in Nigeria today.

Secondly, while there is extensive research done in the field of extractive technologies and operations for and by the international oil companies in the oil and gas sector, the information on energy consumption is limited to aggregate data at the federal level (Akinbami et al, 2001; Sonibare and Akeredolu, 2006). This implies that there is no disaggregated data on electricity consumption or household demographics related to energy access, despite academic discourse on energy poverty in Nigeria being focused primarily on generation capacity and consumption levels (Gujba et al., 2010; Oseni, 2011, 2012). Similarly, energy poverty literature proposes various estimates for minimal per capita energy needs varying from 126kWh to 1000kWh based on research estimates from India and the global north (PA, 2008; Yaeger, 2001). However energy needs vary by standard of living and regional locations because developing countries consume a fraction of what industrialized nations consume per capita (Schoch et al., 2012). There is little information on how much energy to provide per capita in this context as there is no appropriate quantification of electrification needs (Ikeme and Ebohon, 2005). This study addresses this void by computing an energy poverty line for Nigeria that would be applicable to sub-Saharan Africa due to similarities in regional diets, appliances available, household energy needs, and intensity of use (Schwartz and Bardi, 2001).

Third, the wave of privatizing vertical integrated public utilities is the current trend in developing and rapidly industrializing nations. This study proposes an indicator-based transition management strategy with short, medium, and long-term benchmarks that encompass the four themes of environmental, social, economic, and institutional sustainability.

1.2 Research Questions

Three central research questions, and their corresponding sub-questions, are designed to address the state of energy poverty as well as to compute an energy poverty line. They are designed to be stand-alone publications in response to the over-arching question of energy poverty in urban sub-Saharan Africa.

Central research question 1

What legislations, history, and norms have created energy poverty?

Sub-questions

a. What does energy poverty look like in present-day southwestern Nigeria?
b. How did the landscape of the electricity system evolve? What is the history of legislation pertaining to energy?
c. How did the resource-extractive colonial governance institutions impact energy governance?
d. What legislation and norms perpetuate energy poverty?

The current state of energy poverty in Nigeria is described using field and visual data collected from southwestern Nigeria as well as other sources. The electricity sector is a socio-technical system consisting of the physical infrastructure and technology, as well as the institutions created, utilized, and perpetuated by the various actors in the sector. Using a socio-technical systems approach, a long-term analysis of Nigeria's electricity landscape is conducted to explain landscape changes in the electricity sector encompassing the rules and legislation, soft and hard infrastructure, and dominant actors.

Central research question 2

What is the current state of energy poverty in Nigeria?

Sub-questions

a. What is the average electricity consumption per capita?
b. What are energy expenses in relation to the average household income?
c. Are there any dominant consumption trends?

d. What is a context-specific minimum energy poverty line (kWh/capita)?

Aggregate data on electricity consumption in Nigeria estimates 158kWh per capita on average (World Bank, 2012). This value is an average of urban and rural electricity consumption nationwide. In order to get disaggregated estimates, data from field research in urban southwestern Nigeria will be mapped and a context-specific minimum energy poverty line will be computed.

Using conservative estimates of projected population growth, intensity of use collected from surveys, an estimation of end-use energy required to supply basic needs (i.e. power basic appliances including, but not limited to: a television, radio, fans, light bulbs, electric cooker, iron, water pump, as well as supply enough LPG for cooking fuel needs for a year) per household, and then per person would be computed. The power ratings will again be based on the most commonly available brands of appliances found in the region.

This energy poverty line would factor in an estimation of technology adaptation and affluence such as the correlation found by Batra et al. (2000) between developing nations and the desire for consumer goods from non-local sources whose lifestyles they aspired to.

Central research question 3

How can transition to an energy-secure economy be done sustainably?

Sub-questions

a. What is an appropriate sustainable vision for electricity consumption?

b. What benchmarks are appropriate in this transition?

c. How will this transition be managed sustainably within the appropriate sustainability themes?

Transition management involves long-term thinking in framing policy and allows for both slow and fast development. This study uses an indicator-based approach to benchmark progress in electricity access within a short-, medium-, and long-term timeline. Benchmarks are based on the minimum energy poverty line computed from research question two, as well as energy poverty literature.

These research questions are answered in the form of three independent papers each with their own abstracts, executive summaries, methods, and results sections: chapter 2 describes the current state and addresses causation and governance institutions perpetuating energy poverty; chapter 3 uses field research to supply disaggregated data on electricity consumption and access as well as compute a minimum energy poverty line; and chapter 4 concludes by proposing an indicator-based sustainable transition management strategy in light of the move to privatization in the region.

1.3 Study limitations and boundaries.

This study is focused exclusively within south western Nigeria, one of the six geopolitical zones of the country. There is minimal data regarding energy consumption and access in cities. This extends to data on electricity supply, household consumption, and household access. Most initiatives are focused on renewable energy for distributive generation in rural towns and villages.

Southwestern Nigeria is the most affluent geopolitical zone by population (Ibrahim & Ibrahim, 2014). It is also the most politically and religiously stable part of the country unlike the other five geopolitical zones which are fraught with Boko Haram terrorism activities (NW, NE, and NC zones), kidnappings (SS, SE, and NC zones), and civil unrest (NC, and SS zones) (see Fig 1.2) (Dambazau, 2014).

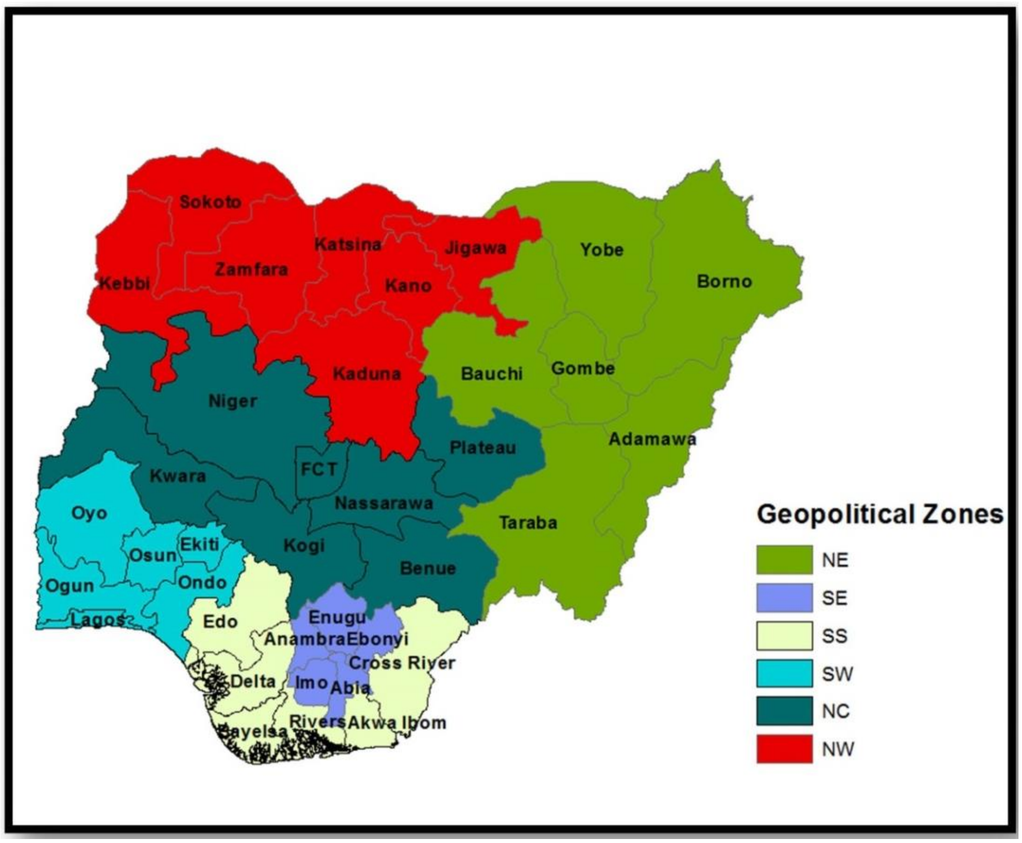

Figure 1.2 Nigeria's geopolitical landscape. *Source*: Author

Also, in compiling data on electricity access, it was found that unlike western cities where there is a geographical boundary between affluent and poverty-stricken neighborhoods, in Nigeria it is typical to find extreme affluence next to abject poverty, both on the same electrical mains supply, and as such households across a wide range of incomes have the same access to power supply (in hours/day). Even though poverty levels in the SW zone are the lowest in the country, the energy poverty experienced in the region makes it an appropriate location for computing a minimal energy poverty line.

1.4 Intellectual Merit

This research gives a systems view of energy from a global north perspective, with the insights of the cultural nuances of the global south, and drawing from different bodies of theory (institutions, socio-technical systems, sustainability science) that are not traditionally considered when addressing energy system of developing sub-Saharan countries like Nigeria. Few studies have been done that look at energy dynamics at this scale, due to limitations in available data, political and religious instability, as well as a dearth of funding.

This study not only supplies data, it proposes a benchmark that is scalable based on population density. Finally it proposes an analysis of cascading effects of institutions of energy poverty, advancing an understanding of strategies that transnational, national, and local actors can use in addressing energy poverty.

Bibliography

1. Bouzarovski, S., & Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty-fuel poverty binary. *Energy Research and Social Science, 10*, 31-40. doi:10.1016/j.erss.2015.06.007

2. Dambazau, A. (2014). Nigeria and Her Security Challenges. *Harvard International Review,* 35(4):65-70.

3. Federal Republic of Nigeria. (2001). A Blueprint for the Schema of National Poverty Eradication Program (NAPEP), Abuja.

4. Handley, G. et al. (2009). Poverty and Poverty Reduction in Sub-Saharan Africa: An Overview of Key Issues. Working Paper 299. Overseas Development Institute. Retrieved from http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/860.pdf

5. Hove, M. et al. (2013). The Urban Crisis in Sub-Saharan Africa: A Threat to Human Security and Sustainable Development. *Stability*, 2(1): 7, pp 1-14.

6. Ibrahim, S.S. and Ibrahim, H. (2014). Budgetary Allocation Dynamics and Its Impact on Poverty Spread among the Geopolitical Zones of Nigeria. *American Journal of Economics*, 4(2): 124-129.

7. Kasali, T.A., Sowunmi, F.A. (2013). The Effect of National Poverty Eradication Programme (NAPEP) Loan on Socio-Economic Development of Ogun State. *Asian Journal of Business Management,* 5(2): 208-212.

8. Otto, G. (2008). *Urbanisation in Nigeria: Implications for Socio-Economic Development*. Owerri: JORIND.

9. Pieterse, E. (2010). Filling the void: Towards an Agenda for Action on African Urbanisation. In: African Centre for Cities Urbanisation Imperatives for Africa: Transcending Policy Inertia . Cape Town: University of Cape Town. pp. 7–45.

10. Poverty headcount ratio at $1.25 a day (PPP) (% of population). Retrieved from http://data.worldbank.org/topic/poverty

11. Schoch, T et al. (2012). Social inequality and the biological standard of living: An anthropometric analysis of Swiss conscription data, 1875–1950. *Economics and Human Biology*, 10: 154–173.

12. Todaro, M. (2000). *Economic Development*. Essex: Pearson Education Limited.

CHAPTER 2

ENERGY POVERTY AS A CASCADING RESULT OF A FAILED SYSTEM: A COMPLEX SYSTEMS APPROACH TO CAUSATION

Abstract

This study explores causation of the state of present day energy poverty in a sub-Saharan African city using cities in southwestern Nigeria as case study. Using a complex systems approach drawing from socio-technical systems theory, institutions theory, and rent-seeking theory amongst others, a long-term analysis of the country's electricity governance as well as a systems analysis of the electricity socio-technical landscape is conducted. This study finds that the kind of colonial governance, ethnic heterogeneity, and public service consumptionism and have the strongest impact on present-day energy governance institutions. These three factors are indelibly interlinked and create the failure of institutions, not just in the electricity sector, but in governance in general.

Executive Summary

This study shows how governance institutional breakdown is created by the kind of colonial governance that a country has experienced, especially in sub-Saharan Africa, and is linked to ethnic fractionalization and beliefs about the relationships between national governance and the governed. These interlinked factors create electricity paucity in Nigeria.

It finds that the greater the number of distinct ethnic identities in a region (ethnic heterogeneity), the greater the preference for trusted acquaintanships in relationships. This mental model makes leadership (from national, regional, to local levels) emphasize the patron-client relationship as the norm, choosing to place kinsmen in vulnerable positions of power.

There is also a unique mentality of civil service consumerism that is specific to countries that were ruled indirectly as opposed to those ruled by direct rule (such as Botswana) and settler rule (such as South Africa). Because colonies were treated as self-sufficient entities by their sovereign government, their administrators focused on the most efficient policies to extract resources. To recruit and retain employees from colonial nations, there was a *status quo* of concentrating public goods and basic infrastructure such as water, electricity, and sewage around residential and administrative areas of local administration. This legacy of government intervention created a mental model of public service and public goods as the exclusive purview of civil servants in the public sector, and belief that the state is solely responsible for public goods such as for schools, hospitals, roads, electricity, and other infrastructure.

In the move towards decentralization and privatization of the electricity sector, accountability is expected to increase as the level of ethnic heterogeneity decreases.

2.1 Introduction

In the electricity system of most developing nations in sub-Saharan Africa, there is an obvious failure of the technical subsystem: one-third of the world's population is estimated to have no access to electricity; half of this population resides on the African continent and live in a state of energy poverty (Pereira et al., 2010). Energy poverty is defined by the UNDP as "inability to cook with modern cooking fuels and the lack of a bare minimum of electric lighting to read or for other household and productive activities at sunset" (Gaye, 2007).

Sub-Saharan Africa contains two of the top twenty oil-and-gas producing nations (Nigeria and Angola) (EIA, 2012). However both of these countries are the bottom twenty worldwide for electricity consumption per capita[1]: Angola (145 of 163 reported countries) at 248 kWh/capita; and Nigeria (154/163) at 149 kWh/capita (WB, 2012). With household electricity consumption an indicator of local economic development (Goldemberg et al., 1985) and the informal sector constituting fifty percent of the economy in developing nations like Nigeria (Meagher & Mohammed-Bello, 1996), the electricity sector in sub-Saharan Africa is one of the most under-developed, creating pervasive energy poverty in the region.

It is important to note that energy poverty is disparate from fuel poverty. The former is primarily used in the developing-world context to describe lack of access to adequate facilities for cooking, lighting, and electrical appliances. It is driven by low levels of electrification, poor or inadequate infrastructure and non-functional institutions, resulting in low economic development and other social issues. The latter is used in the developed-world

[1] For all countries for which electricity consumption was reported in 2012.

context and refers to inadequate heating in the home due to high or rising energy costs in relation to low household incomes resulting in impacts to short- and long-term mental and physical health impacts (Bouzarovski & Petrova, 2015).

There is a wealth of anecdotal and peer-reviewed literature examining links between natural resources, development, and poverty in developing countries in general, and in sub-Saharan Africa in particular.

Anecdotal literature such as Michael Peel's *A Swamp Full of Dollars* and Nicholas Shaxston's *Poisoned Wells* depict the realities of civil unrest resulting from failed governance institutions tied to the energy sector in oil-rich sub-Saharan African countries. Okonta & Douglas' *Where Vultures Feast* address social justice, power dynamics, and conflict specific to resource extraction in Nigeria's Niger Delta region. Similar themes are also portrayed by Michael Watts' *Curse of the Black Gold*, exposing the social, environmental, and economic costs of exploitation of oil, as well as the power dynamics, poverty, and conflict in the Niger Delta region. These literature address energy poverty through its most visible symptoms: conflict, lack of security, social inequity, pervasive poverty, and environmental degradation. They however stop short of exploring causation.

In academic literature, Macartan Humpreys' et al.'s *Escaping the Resource Curse* explores the weak institutional structures and mechanisms of accountability, and suggests policy to mitigate the resource curse in resource-rich African nations. Michael Ross' *The Oil Curse: How Petroleum Wealth Shapes the Development of Nations*, argues that the presence of oil has a stronger negative effect on development than other minerals. Examining resource-rich countries in Africa, South America, the Middle East, and Eurasia, he links weak governance, civil conflict, and poor economic performance to the unique properties of oil: scale, source, stability, and secrecy. Ross provides a rich analysis of present-day resource curse issues drawing from case studies of those countries. The prevailing themes in these literatures are the resource curse, rent seeking, and the Dutch disease: historic context on causation is missing.

Rent-seeking literature claims that phenomena such as energy poverty are a side-effect of the resource curse, caused by poorly evolved democratic institutions and dysfunctional patronage (Damania & Bulte, 2003; Mehlum et al., 2006). It posits that endogenous and exogenous factors create energy poverty and slow economic growth in Africa. Endogenous causality is attributed to factors such as the power imbalance between sub-Saharan African states and the extractive industry, the lack of political freedom (Le Billion, 2005; Ross, 1999) and democracy (Andersen & Ross, 2014; Aslaksen, 2010; Ross, 2001; Tsui, 2011), bad fiscal policy (Pegg, 2010), power relations (Caselli & Cunningham, 2007) and geographic and public health issues (Daniele, 2011; de Soysa & Gizelis 2013).

Within this literature, exogenous causality is linked to post-colonial legacy, specifically the political and economic relationships between Africa and the West (Basedau & Lay, 2005) and price volatility of natural resources (Van der Ploeg & Poelhekke, 2009). However, the combination of exogenous and endogenous factors fail to sufficiently explain the success of developing countries such as Chile, Botswana, Malaysia, and Indonesia (Sarraf and Jiwanji, 2001; Acemoglu et al., 2003; Iimi, 2006; Stevens, 2006).

In these literatures (resource curse, rent-seeking), scholarship of the political economies of energy across the region limits causation to post-independence governance institutions. Bostwana, located in the southern region of Africa, is a resource extractive state that was a colony of the British Crown, yet it does not experience the same levels of governance institution weakness or energy poverty. The literature fails to provide contextual linkages between the history of resource extraction and governance that explains this outlier.

Thus it ignores the conditions under which the institutions were formed, thus analyzing the symptoms instead of the causes (Stevens & Dietsche, 2008). For those countries that are outliers, what factors determined the decisions by its leadership specific to transparency, power dynamics, fiscal policies, and governance?

On the other hand, energy poverty scholarship in the last decade has focused on rural access. Other themes include distributed generation for rural electricity access via renewables (Williams et al. 2015; Akinbulire et al, 2014; Kamalapur, 2008), quantification of energy access (Pereira et al., 2011; Pachauri et al., 2004; Chidebell-Emordi, 2015), energy policy (Sullivan & Barnes, 2007; Sagar, 2005; Tharakan, 2007), and social equity (Oparaocha & Dutta, 2011; O'Dell et al., 2014).

Energy poverty literature on sub-Saharan Africa is dominated by descriptive data on the current state (indices of development and corruption, rural access for electrification and cooking fuels), quantifying energy access, small scale rural projects to provide sustainable technology (solar microfridges, efficient cookstoves, etc) and electricity from renewables. These themes all fall within the scope of energy poverty in rural sub-Saharan Africa. However rapid urbanization is occurring with increasing stress on the limited economic, social, and environmental resources in the cities. With rural-urban migrations expected to increase within the region over the next 30 years (Cohen, 2006), the issue of energy poverty in cities in sub-Saharan Africa is important in the general discourse on poverty and sustainable development.

This study posits that within the sub-Saharan African region, typeology of colonial governance, cultural/ethnic heterogeneity, and public service consumptionism (mental models about the relationship between the national government and public goods) determine the strength of post-colonial governance institutions, and consequently, energy policy.

2.1.1 Why is it important to understand causation from a historical perspective?

Studies of energy poverty show strong links between poverty and energy access, creating a vicious cycle because households without energy services are trapped in deprivation (Masud et al., 2007; Mishra, 2015). However, the wave of electricity sector reform pushing decentralization and privatization in developing countries is based on economist theories that privatization will bring benefits to a sector plagued by inadequate supply and access, amongst other institutional limitations. This implicitly assumes that increasing electricity production means access for all and therefore mitigates energy poverty.

This has not been found to always be the case when global best practices models of privatization are employed. Such was the case of Uganda, Kenya, and Tanzania where privatization did not eliminate issues with regulation, accountability, and transparency in the national electricity system (Hall, 2007; Keating, 2006). This trend seems to hold true for Nigeria which is at the early stages of privatization of its electricity sector. In 2013 Nigeria unbundled its electricity sector into three infrastructure entities: distribution companies, generation companies, and a transmission company. Within the first year of privatization generated capacity declined from an already low 4517 MW to 3670 MW with little noticeable changes in the institutional functioning – tarrifs, regulatory bodies, supply and access, as well as infrastructure failures (Joseph, 2014). It is important to know if privatization efforts are following an appropriate sustainable transition pathway within the context of the electrical sector socio-technical system.

Secondly, historical perspectives are important in explaining path dependency in a technological system within its financial, social, and institutional components (Van der Vleuten & Raven, 2006). Electricity systems that are vertically integrated utilities are characterized by the involvement of multiple actors, complex and multi-layer institutions, laws, regulations, and policies and need to be studied from a socio-technical systems approach (Sovacool, 2014). Within Nigeria's electricity system, path dependency that creates energy poverty is explored using a long-term analysis of the socio-technical regime, adapting a similar approach by Verbong and Geels (2007). This is done in a two-fold analysis: the first is a systems analysis of the electricity landscape to determine the dynamics of the electricity sector. This extends to the rules, infrastructure, and dominant actors within the landscape from the inception of the electricity sector to date; the second analysis delves into causation and explains the electricity landscape through its governance institutional history.

Finally, electricity sector transitions occurring in sub-Saharan Africa have been studied with a focus on deployment of renewables in rural locales (Ahlborg & Sjöstedt 2015; Ulsrud et al., 2015). There is a paucity of scholarships with a socio-technical systems analysis of the electricity sector of its national grid especially in cities. This paper contributes to scholarship in this niche.

To the author's knowledge, this is the first attempt to determine causation of institutional failure in the national electricity system of a developing energy-poor sub-Saharan African nation using a long-term analysis of its socio-technical regime and focusing on large-scale electrical utilities.

2.2 Analytical framework

The theoretical framework in this study utilizes a long-term analysis of the electricity sector using the Multi-Level Perspective (MLP). Large technical systems such as the electricity sector are deeply woven into the overall structure of society and as such, evolve with changes in society and the economy (Hughes 1983; Hughes et al., 1997). The MLP has been used to illustrate and analyze the impact of society on innovations and transitions within the electricity sector: Kamp and Vanheule (2015) show that socio-cultural factors as well as mental models inhibit the growth of the small wind turbine (SWT) niche sector in Kenya; similar work done by Yuan et al. (2012) use the MLP to show that pressure from socio-economic transitions due to accelerated industrialization are primary inhibitors to a low-carbon transition pathway in China's electricity regime; Sutherland et al. (2015) use the MLP to illustrate how niche innovation in the renewable energy sector is driven by the agricultural sector with farmers in Germany, the Czech Republic, and the UK being the first to experiment with biogas (from manure) and wind energy.

The MLP gives insight into the external environment in which the electricity sector has developed over time and will be used to analyze Nigeria's electricity sector within the case colonial and post-colonial Nigerian society. This paper models the MLP analysis after Verbong and Geels' (2007) long-term analysis of the Dutch electricity system to determine factors that supported and opposed transition to renewable energy options in the Dutch electricity generation portfolio mix. It was found that changes in the dynamics of the electricity sector occurred slowly over time: the Dutch electricity sector became decentralized and production and distribution of electricity became separated; the sector became ruled by market mechanisms instead of internal top-down mechanisms which changed the mind frame from an engineering-based one to that of profits, shareholder value and managerial mind-frame; rules and social networks of the sector changed, creating new actors with new roles.

Similar to the transitions in the Dutch electricity system, the Nigerian electricity system is a monopoly ruled by internal top-down mechanisms. Both systems were initially top-down and transitioned (or in the case of Nigeria, is transitioning) to a market-driven system, evolving slowly over time as they became decentralized.

Focusing on the regime level of the MLP, this study makes a long-term analysis of Nigeria's electricity domain. Section 3 covers data collection methods, section 4 describes energy poverty in Nigeria today; section 5 analyzes dynamics in the social networks, rules and technologies; section 6 analyzes recent changes in the system (privatization, MYTO) and projected trajectories; section 7 combines both analyses to explain the current state of the energy system and the resultant energy poverty; Section 8 concludes the discussion on complex adaptive systems and energy poverty.

2.2.1 The Multi-Level Perspective

The MLP consists of three levels (Geels, 2002): niches, regimes, and the landscape of the STS (see Fig. 2.1). Niches serve as incubation rooms for new technologies at the micro-level where innovations (technological or market) occur, building social networks and learning processes (Verbong & Geels, 2007). In the Nigerian electricity system, there is virtually no innovation occurring due to the absence of an R&D allocation in the national energy budget.

There is opportunity for adapting leap-frog technologies that have been successfully tested in other energy markets as is on-going in the telecommunications industry. One such example is the recent introduction of pre-paid metering.

The overall electricity landscape forms the macro-level of the MLP which evolves slowly and impacts niche and regime dynamics (Verbong & Geels, 2007). The electricity landscape in Nigeria, as in most of sub-Saharan Africa, is dogged with multiple policy shifts at the federal level, and non-existent supply at the household level. However, the majority of the energy system dynamics takes place at the *meso*-level of the socio-technical regime.

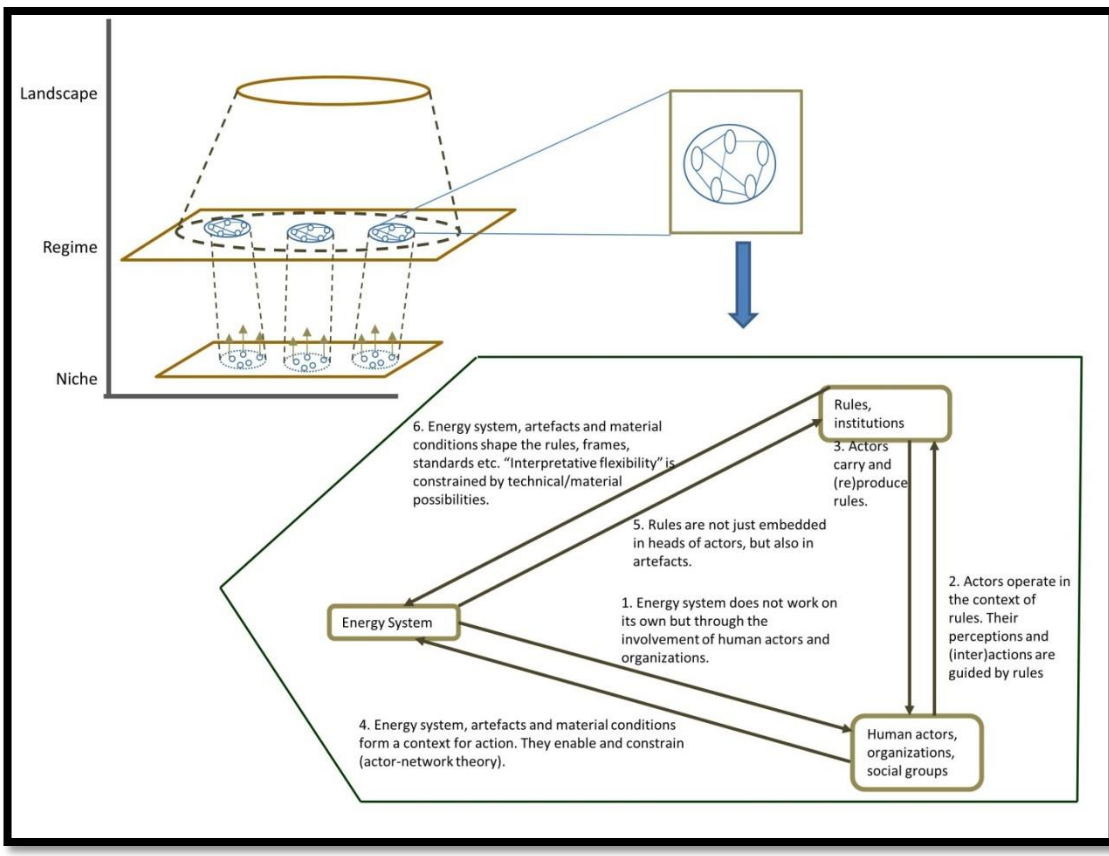

Figure 2.1. Multiple levels of MLP featuring dimensions of the electricity sector sociotechnical regime. Adapted from Geels (2002, 2004). *Source*: Author.

The study focuses on the socio-technical regime which is the *meso*-level of the MLP. Regimes are created by patterns in energy systems–rules embedded in engineering practices, skills and procedures, ways of defining problems, ways of handling persons and the attendant artefacts - that become embedded in institutions and infrastructure (Rip & Kemp, 1998, p. 340). These sociotechnical regimes reinforce existing technological patterns in many ways: creating cognitive routines that are resistant to novelty (Nelson & Winter, 1982), regulations and standards (Unruh, 2000), adapting lifestyles to technical systems, as well as sunk investments in physical technology and infrastructure (Tushman & Anderson, 1986; Christensen, 1997). In some energy systems these regimes create and perpetuate energy poverty. This is because these actors impact, and are in turn impacted by, each other. They adapt and respond to each other and artefacts but unlike actors in a typical econometric model, actors in a complex adaptive system like Nigeria's electricity system lack rationality and foresight in their interactions (Foster, 2005). These interactions are done via physical and social networks, and influenced by norms and institutions. Since actors have their vested interests that, within the stabilized regimes, make them resistant to change, it is important to determine the dynamics between the social and technical subsystems that create energy poverty.

The socio-technical regime consists of three interlinked dimensions – the electricity system itself, the actors, and the rules and institutions within which the actors operate (Fig. 2.1). The electricity system refers to the hard infrastructure (i.e. the generation plants, the electrical grid, substations, and local distribution) as well as the soft infrastructure (tariffs, financing, and trained technical personnel). The actors range from households, industry and businesses, to energy producers and suppliers, economic and environmental regulators, as well as policy makers and government. The rules and institutions refer to codified laws, regulations, and policies regarding the electricity sector, as well as cultural attitudes and norms about the sector that impact the modes in which the actors interact with the energy system.

Within STS literature, STS analysis is typically used for analyzing more mature electricity systems in the context of climate change, energy security, and other drivers of technological change (Magnusson, 2012; Foxon, 2013; Galvin & Sunnika-Blank, 2014; Einsieden et al., 2013; Bolton & Foxon, 2015). In electricity systems of developing nations, the predominant trend in STS literature is analyses focused on adaptation of renewable energy for distributed generation at the rural level (Ulsrud et al., 2011; Sovacool et al., 2011; Sesan, 2012; Müggenburg et al., 2012). There is a gap in STS literature aimed at the functioning and effectiveness of large-scale electricity systems in developing nations. This is important to get a holistic view of how the systems function, especially as energy poverty is a direct result of failed electricity systems in developing nations: in this paper, electricity is used as a proxy for cooking fuel, and is required for lighting and powering cottage industry (C-Emordi, 2015).

Drawing from literature on path dependency and mental models, as well as data from historical legislation, expert interviews, archival databases, this paper devolves the energy system by showing how these aforementioned factors enable and perpetuate energy poverty within the regime level of the MLP. This would be done through a historical analysis of the electricity landscape in Nigeria to determine the mental models, changes in ministerial oversight, and path dependency in Nigeria's electricity socio-technical system.

2.3 Methods

The data used in the long-term analysis of the electricity system is based on information collected in the field, historical archival analysis of documents including electricity data from the Nigerian Electricity Regulatory Commission (NERC), natural resource governance information from the Nigerian Constitution, and information on colonial-era governance institutions from "The dual mandate in British tropical Africa," written in 1921 by Lord Lugard, the British crown's administrator over its protectorates in West Africa. It is a comprehensive compilation of governance policies used by the British Crown in Africa. In addition, peer-reviewed articles were obtained by means of search engines of scientific publishers including Elsevier/ScienceDirect, SpringerLink, and Scopus. Other studies not reported in journals, such as governmental analyses and international journals, were searched by means of the Google Scholar search engine.

All information from literature and national documents was analyzed via data reduction methods with the data sorted, categorized, and prioritized based on relevant emerging themes (Blum & Langley, 1997).

2.3.1 Data collection

This study used a convergent parallel design of the mixed-methods approach, collecting both quantitative and qualitative data simultaneously. The quantitative data was used to measure distinguishing characteristics, elemental properties, and empirical boundaries of the specified variables (Nau, 1995). Qualitative data was used to gather an understanding of lived experiences as a group or at the individual level (Silverman, 2006). Qualitative data was obtained via participatory research which helped to understand the subtle nuances of the state of energy poverty within its context and reduce the distrust of the people being studied (Macaulay et al., 1999, pg. 774). It also helped to understand social actor's perspectives, as well as validate data obtained from other sources (Londof, 1995).

Initial informal interviews were carried out via random sampling in December 2012 at the University of Ibadan, Oyo state. For these surveys, participants were randomly selected from the university employees, contractors, vendors, students, and visitors via convenience sampling. The purpose of these preliminary interviews was to understand local perspectives of energy issues, gauge understanding of technical terminology, and ascertain appropriate framing of questions (for instance when collecting data on household demographics we found that in certain settings it is inappropriate to directly ask "how many children do you have?" because it implicitly assumes that the respondent has children[2]; instead we asked "we know that God blesses us with children, how many children do you have so far?"). These unstructured interviews also enabled us to build trust with prospective interviewees for future structured surveys.

The second phase of data collection was conducted in June 2013 in urban locations in three southwestern states: Lagos, Osun, and Oyo states. Both quantitative and qualitative data were compiled from multiple sources namely: field research in the form of household surveys, expert interviews, and group interviews.

Household interviews were conducted by convenience sampling to collect data on actor dynamics pertinent to electricity access. A total of 105 households (n = 105) were interviewed: 46 households in Oyo state, 49 households in Osun state, and 10 households in

[2] There are a couple reasons for this – first, there is strong stigma associated with being a married woman and not having children. Secondly, there is a preference for male children and this must determine the order of gender when inquiring about children : girls first, then boys. Third, even though infant mortality rates have consistently dropped over the past decade, it still occurs and in Nigeria (as well as other parts of sub-Saharan Africa) it is taboo to speak of children who have died.

Lagos state. Households were selected randomly from neighborhoods located near large markets due to time and logistical constraints.

The survey was modeled after the Mimmi (2014) study designed to collect data on household energy use. The question types include dichotomous as well as nominal-polytomous close-ended questions with equal priority given to both qualitative and quantitative responses (Creswell & Plano Clark, 2011). These cross-sectional surveys were conducted via face-to-face interviews in public places (store fronts, mixed-use dwellings). Interview questions were broadly categorized into household demographics, energy access in the form of electricity supply, consumption, and affordability, as well as environmental and human health services.

Recruitment for group interviews and expert interviews was accomplished via chain sampling. The researcher initiated prospective stakeholders to participate and make recommendations for additional candidate that fit the research criteria (Biernacki & Waldorf, 1981).

Expert interviews and group interviews were conducted on the campus of the Federal University of Ibadan in Oyo state, Nigeria. All candidates consented to interviews after receiving in-person description of the study and their prospective roles. Due to subtle cultural nuances that influence power dynamics, three separate sets of group were conducted: with undergraduates, graduate students, and lay-people. The researcher took care to minimize gender bias as much as possible, as well as "false" consensus from dominating participants (Litosseliti 2003 pp 22).

Group interview questions were open-ended and pertained to the participants' beliefs and mental models about energy governance and public goods consumption. Most questions were open-ended or semi-structured about specific aspects of the electricity system. Group interview sessions ran for approximately one hour. Saturation occurred when no new themes emerged.

These were complemented by qualitative interviews with experts in Nigeria's energy sector. For the purpose of this study, experts refer to Nigerian nationals who are professionals in Nigeria's oil and gas sector. This study limits the scope to those who have represented the country at national and international level deliberations such as the NNPC, the World Bank, the United Nations, and the Department for International Development (DFID). For expert interviews, questions were more in-depth, eliciting information on the actor networks and the physical electricity grid. Interviews lasted for roughly 40 minutes each.

Saturation size was achieved at 15 participants for group interviews and 5 participants for expert interviews due to the nature and scope of the topic (Morse 2000 pp 4).

Before integrating qualitative and quantitative data, each dataset was analyzed and interpreted separately according to the process described by Rosenberg et al. (2013). Next, general themes were identified and coded based on relationship to quantitative data collected. Finally the information extracted was used to inform gaps in literature review and quantitative data collected.

2.4 What does energy poverty in Nigeria look like?

Low-density energy fuels are the primary source of fuel for cooking and lighting. Of the urban households surveyed, 88% used some mix of cooking fuels including firewood, kerosene, gas and electricity with almost a quarter of the households (23%) using a mix of firewood and kerosene, the least dense fuels (Figs 2.2, 2.3).

Fig 2.2a Energy poverty in Nigeria.
Source: The Borgen Project.

Fig 2.2b Nigeria Power employee works on a tangle of lines in Lagos.
Source: Sunday Alamba/Associated Press

Blackouts and brownouts (locally referred to as *low current*) are the norm in urban southwestern Nigeria with The average number of hours of daily power supply was 9.5 hours in Lagos state, 10.7 hours in Osun state, and 7.2 hours in Oyo state with most households receiving between 1 and 8 hours of electricity supply across the three states (Fig 2.4).

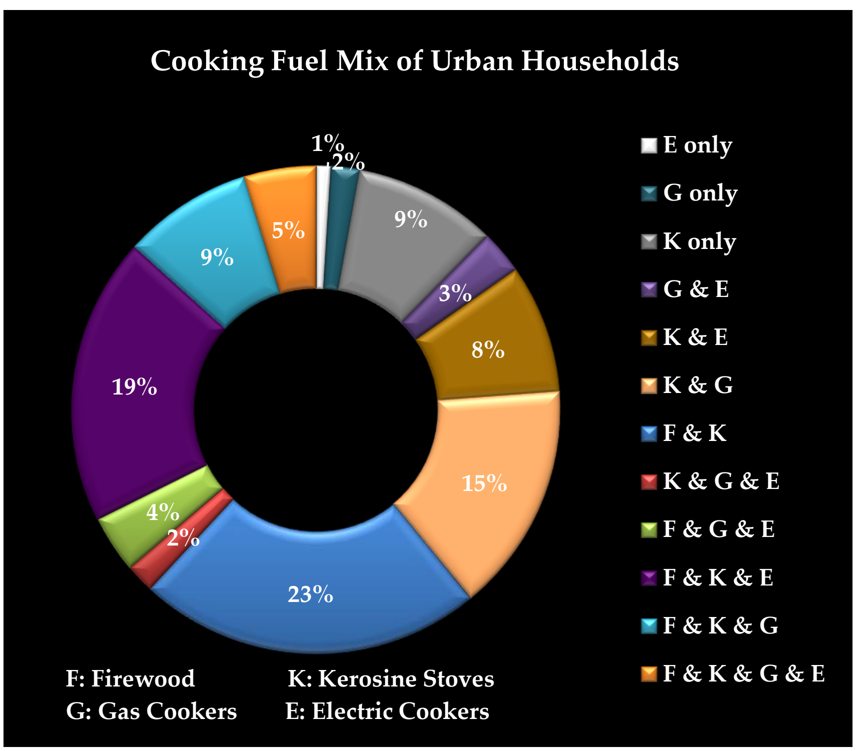

Fig 2.3 Cooking fuel mix of urban southwestern Nigerian households. *Source*: Author.

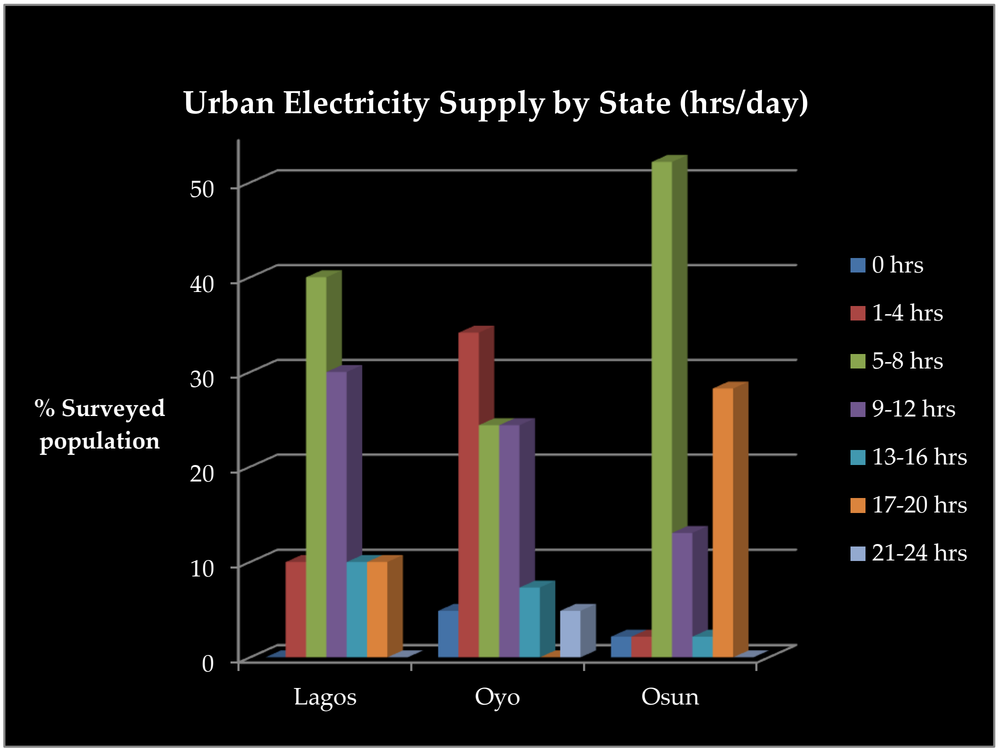

Fig 2.4 Average Electricity Supply by State. Source: Author

Kerosene lamps and candles are used for lighting after sunset for households that cannot afford a generator. Private self-generation with portable generators accounts for electricity supply for 72% residents in urban southwestern Nigeria (Chidebell-Emordi, 2015) creating in Nigeria, the world's largest concentration of small-scale generators (Economist, 2010). These clusters of generators in both residential and commercial buildings contribute to air pollution in the form of SOx, NOx, and particulate matter as well as noise pollution (see Fig 2.5) and have been documented as contributing to the rising asthma prevalence in Nigeria (Awofeso, 2011; Sonibare et al., 2014).

The state of electricity supply adversely affects the manufacturing sector: companies that are large enough, such as the Delta Steel Mill, the Aba Textile Company, and Dangote

Cement, own their own thermal power plants and source natural gas to operate it directly from the Nigerian Gas Company via independent operators (NNPC, 2010).

Other estimates have put private generation for businesses at 90% of electricity needs. Trans-national corporations like Coca-Cola and Procter & Gamble rely on self-generation for 100% of their power supply (Connors, 2009). For smaller scale and cottage industries, the costs of continuous operation are too high, reducing the productivity of income-generating activities.

Fig 2.5 Cluster of portable generators outside a local business area. *Source*: Dada Joseph

There is also the social inequity associated with energy poverty - for energy-poor households that depend on firewood and charcoal, it is the responsibility of the females and female children to collect the biofuels, often walking distances that take away time from income-generating activities and education (Reddy & Nathan, 2013). This loss of human, economic, and social capital is in addition to indoor air pollution associated with traditional fuels. Thus energy poverty is truly multi-dimensional from its social impacts in the form of health, equity, access, and education of women to economic impacts reducing productivity and income generating activities, energy poverty retards overall development.

Fig 2.6 Young girls collecting firewood from drainage gutters in Ibadan. *Source*: Author

2.5 Dynamics of the Electricity Sector

Drawing from data on generation, transmission, and distribution as well as governance institutional structure from Nigeria's electricity regulatory body, NERC; published studies on current system challenges, as well as historical and archival analysis of Nigeria's electricity sector, this paper explores the dynamics in the electricity sector from the colonial era when it was first introduced, to the present day. It also briefly discusses the dominant actors relevant to the electricity landscape, as well as the electricity market.

The rules governing Nigeria's electricity sector have evolved over time with the change in governance from colonial governance to post-independence. These changes can be broadly categorized as the pre-independence regime, and the post-independence, pre-privatization regime. The changes in infrastructure, controlling bodies, and regulatory oversight occurred at the regime level and are subsequently discussed.

2.5.1 Pre-independence (1896-1960)

Electricity was first produced in the colony and protectorate of Lagos, Nigeria in 1896 with a total generation capacity of 60kW (Okoro & Chikuni, 2007). Niche dynamics in the global electricity sector were occurring in the industrialized world with the introduction of electricity to homes and businesses at the beginning of the nineteenth century. In Lagos, the administrative center of the protectorate, street lighting was introduced as early as 1898 but was limited to the European residential area (Olukoju 2003, pp. 21). According to Olukoju (2003), due to the prohibitive costs at the time, electrical power supply was extended only to a few strategic administrative buildings, the hospital and the government house. Power supply was rationed and switched off at 11 p.m. because the annual cost of the staff and fuel required to operate and maintain the thermal power plant was almost £2,000.

Subsequently, the political climate began to shift with the Northern and Southern protectorates merging with the protectorate of Lagos to become the colony and protectorate of Nigeria in 1914. The country then became an amalgamation of these three separate regions – the North, East, and West with local administrations that were overseen by the colonial government through indirect rule, the impacts of which will be discussed later. By 1929, the electricity system consisted of the Nigerian Electricity Supply Company (NESCO) which began generating and distributing power in Jos, as well as the Native Authorities in other parts of the country (Barros et al., 2014). At this time street lighting was extended to other areas of Lagos state and funded by a tax rate of nine pence per unit annually.

In 1946, the British colonial authority created the public works department (PWD) under whose jurisdiction the creation and supply of electricity in Lagos fell. However, although electricity was supplied to an increasing proportion of Lagosians, regulations were introduced to ration supply. This was for two reasons: demand was fast outpacing supply; and materials for maintenance had to be shipped from Great Britain (Olukoju, 2003). The details of these restrictions included: permanent disconnection of residences of consumers for non-payment; non-issuance of permits for appliances not restricted to off-peak usage; non-issuance of permits for temporary illumination; and limiting applications for new residential electrical installations to minimal illumination.

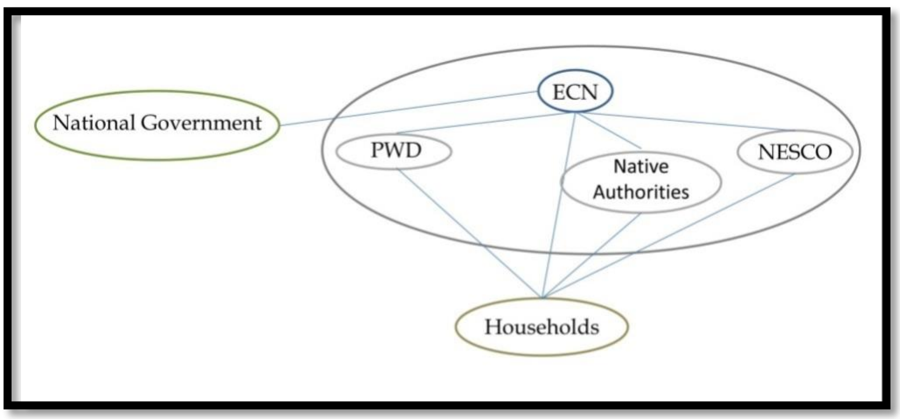

Figure 2.7. Actors and networks in electricity regime pre-independence. *Source*: Author

By 1950, a central electricity supervisory body, the Electricity Corporation of Nigeria (ECN), was formed to control all existing thermal power plants. The organizing principle went from municipal and regional control, to a vertical public operated utility. The power sector was under centralized administration with the authority to mandate tariffs and regulate utilities under the purview of the ECN (see Fig. 2.7). The regime level of the electricity system thus consisted of the native authorities, NESCO, and the PWD as the principal actors subject to the jurisdictional authority of the regional colonial government.

The physical infrastructure of the energy system was a disjointed one, limited to locales that were the seat of local administration. This included the cities of Lagos in the southwest, the seat of the central government, Kaduna, the seat of the Northern Provinces, and Ibadan, the seat of the Southern Provinces. The cities of Calabar, Port Harcourt and Kano also housed members of the Legislative Council. (SYB, 1940). The generation, distribution, and transmission infrastructure were small-scale and manageable, maintained by skilled workmen supplied by the Crown (Olukoju, 2003).

The electricity landscape was controlled at the macro-level by the colonial regional government. This included creation of the country's first energy legislation, policies, and regulations (Oke, 2013). This soft infrastructure of the electricity landscape was encapsulated in the overarching energy infrastructure.

2.5.2 Post-independence, pre-privatization (1960-2005)

Post-independence, the Nigerian electricity system underwent major upheavals. The landscape changed from one in which the governance of the system was a mix of native authorities and national power generation companies, to one nationalized bureaucratic entity. The changes in the landscape started with the creation of the Niger Dams Authority (NDA) in 1962 to develop hydro power stations. Ten years later both the ECN and NDA were merged to form the Nigerian Electric Power Authority (NEPA) through the NEPA Act of 1972. The intent of the act was twofold: to homogenize the tariff rates and assume responsibility for the financial obligations of the electricity sector; and to more effectively utilize human, financial, and physical capital to ensure widespread supply of electricity throughout the country (Okoro & Chikuni, 2007).

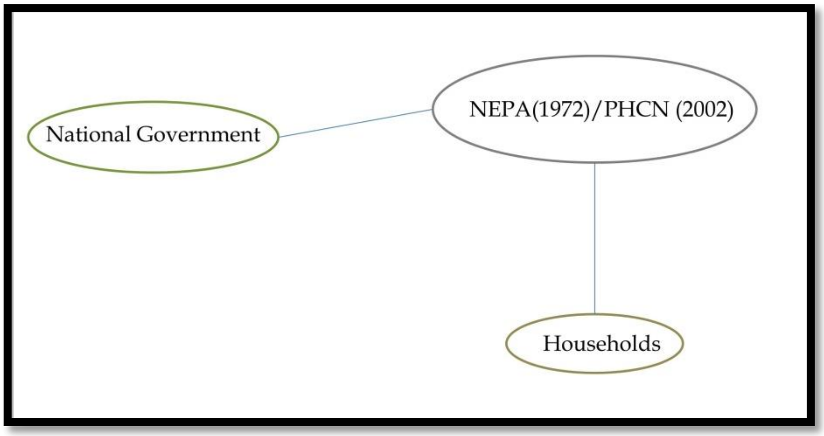

Figure 2.8 Nigeria's electricity regime (1960-2013). *Source*: Author

NEPA had the monopoly of electricity generation, transmission, and distribution. It was also a self-regulating agency, without outside checks and balances. Between independence and 2010, 27 power plants were commissioned (Ibitoye & Adenikinju, 2007). As the population grew, the country's generation capacity did not have a corresponding growth. The infrastructure also began to age and fail, and with the deep regional and ethnic divisions that persisted, new administrations sought to impact the deficiency in supply with quantifiable milestones. These manifested in the form of constructions of new power generation plants. Over time, this became a pattern such that succeeding administrations, often from very different ethnic groups than their predecessors, resorted to new power generation infrastructure construction to mark their time in office. The exception to this rule was with the military dictatorships which were purely rent-extractive. There are currently 21 operating power plants connected to the national grid: 3 hydro, 2 steam, 14 gas, and 2 combined gas/steam (Oyedepo et al., 2014). In all the total installed capacity is 10.897 GW. However they all operate at less than 50% of capacity. This is attributed to infrastructure failures, poor management practices, and economic sabotage (Oseni, 2012). In addition to the problems associated with electricity generation, there is about 30-47% of loss in electricity transmitted due to outdated infrastructure and resistive losses (Akpabio & Akpan, 2010). There is no information on the distribution network to ascertain actual consumption patterns, as well as a scarcity of trained technical personnel to maintain and run the infrastructure. Between 1980 and 2011 there has been an increasing investment in hard infrastructure without the corresponding investment in soft infrastructure (skilled workforce, maintenance regimes, research and development).

On the consumer side, tariffs are the lowest in Africa due to federal subsidization and as such, the revenue generated is insufficient to operate the electricity supply system (Ibitoye & Adenikinju, 2007). For consumers who experience persistent blackouts, monthly electricity bills are generated for the same amount whether or not electricity has actually been supplied that month (Chidebell-Emordi, 2015). If payments are not made, the electricity bill continues accruing. Customers pay some portion of the bill to remain connected to the electricity grid.

In addition there are a significant number of unmetered consumers, specifically households and cottage businesses that simply tap into the electricity grid from any nearby transmission line, leading to load shedding and brown-outs. There are legitimate attempts to own meters: it is typical for individuals to prepay for a meter and be put on waitlists that last for years (Vanguard, 2013). However, the distrust those electricity consumers have for the federal electricity body has perpetuated an indifference to attempts at change in the electricity sector. This apathy creates path dependency, perpetuating the rules and mental models of inefficiencies of government-run institutions.

From its inception to its dissolution in 2005, NEPA was unable to meet the increasing electrical power demands of a growing Nigerian population. At this point the economies of scale that make a vertical operated public utility a viable monopoly (Kahn,

1989) ceased to exist and the view was towards privatization as a means to address inefficiencies in the electricity sector.

The Nigerian Electric Power Policy (NEPP) was created in 2002 to overhaul electricity sector legislation. It was tasked to: draft a new electricity law, establish an independent regulatory agency, develop a wholesale electricity market, provide subsidies for less privileged Nigerians in the form of a consumer assistance fund, and establish a Rural Electrification Agency (REA) to create and manage a consumer assistance fund targeted at rural electrification projects for rural customers (NERC, 2008).

2.5.3 The Electricity market

The energy market in Nigeria has always been some kind of monopoly (see Table 2.1). When the sector first started producing electricity, the market was open to electricity generation by native authorities, however the size of the national power generation company (NESCO) created a natural monopoly for tariff structures. Subsequently the power industry became a government monopoly under the supervision of the Electricity Corporation of Nigeria (ECN, 1950) which then became the National Electric Power Authority (NEPA, 1972), and eventually the Power Holding Company of Nigeria (PHCN).

It is important to note that as demand for electricity outpaced the available supply, self-generated electricity came to play a dominant role in the country's electricity sector. The generator industry is itself a monopoly (popularly known as the generator mafia) and an active part of the electricity sector (Garside, 2011).

The suppliers of the electricity sector include the replacement parts market for both hydro and thermal power plants, and natural gas supply for thermal power plants. The generating and transmission infrastructure are old models that are outdated and incapable of carrying the current load demands. In addition, the parts are not available when needed due to the non-existence of a maintenance budget (Oyedepo, 2014).

The fuel needed to power the thermal plants is typically supplied via Gas Supply Agreements (GSAs). GSAs are negotiated between the generating companies (GENCOs) and the independent Exploration and Production (E&P) operators of the mining leases that are obtained from the Nigerian Gas Company. Currently, thermal power plants are commissioned without sufficient fuel to make them operational (Akinosho, 2013).

Industry is the largest competition for gas supply to the power sector. These industries include steel companies, cement production factories, textile mills, and chemical companies (NNPC, 2010). This competition is due to the fact that the negotiated agreements are for low fixed prices which are often not paid (Makan, 2013). Marginal field operators in the oil and gas sector thus have a preference for industry with which they have a more reliable financial arrangement.

Table 2.1 Governance institutions of the Nigerian Electricity System

Time Period

	1896 – 1946	1946 – 1950	1950 – 1972	1972 – 2013	2013-
Utility Type	Municipal Utilities	Vertical integrated national public utility	Vertical integrated national public utility	Vertical integrated national public utility	Private generation and distribution companies, public transmission company
Market	Natural monopoly	Natural monopoly	Government monopoly	Government monopoly	Open market, Government monopoly
Dominant Actors	Municipalities	Municipalities, national government	National government	National government, generator importers	Private companies, independent regulator

The low electricity tariffs impact the government-specified GSA rate, which in turn discourages independent operators from developing fields known to only contain gas as opposed to both oil and gas.

The primary consumers of Nigeria's electricity are the cottage industry, households, and industry. The dismal power sector makes large scale manufacturing prohibitively expensive such that the manufacturing sector only contributes 4% of national GDP (Economist, 2010). Manufacturing companies that are large enough, such as the Delta Steel Mill, the Aba Textile Company, and Dangote Cement, own their own thermal power plants and source natural gas to operate it directly from the Nigerian Gas Company via independent operators. For smaller scale and cottage industries, the costs of continuous operation are too high, reducing the productivity of income-generating activities.

Self-generation has made it possible for the cottage industry, which comprises 80% of all registered businesses, to thrive in the midst of blackouts and brownouts (Ogechukwu, 2011). It is increasingly affordable to purchase a portable 1kW power generator for about $100 US, albeit constituting a loss to the economy of $130 billion US annually from both households and businesses (ASI, 2015). The dependence of the country's economy and government on self-generation has made generator importers a powerful voice in Nigeria's power sector. With the potential loss of business in urban areas, there is no incentive for this lobby to support electricity reforms, requiring strong regulatory enforcement for legislation that improves infrastructure maintenance and performance going forward.

2.6 Recent changes in the energy landscape

In the recent path to privatization, there was a mass restructuring of the electricity sector. New legislation and regulatory policies were put in place, and new technologies were proposed for this evolving landscape. These changes, as well as projected trajectories of the system, are subsequently discussed in light of the historical energy governance institutional challenges.

2.6.1 The path to privatization (2005-2013)

In 2005 the Electric Power Sector Reform Act (EPSR) repealed the NEPA Act and the Power Holding Corporation of Nigeria (PHCN) was formed to serve as a transitory holding company in preparation for the restructuring, unbundling, and privatization of the electricity sector. In preparation for this transition, the EPSR Act further provided for the creation of "Successor Companies" comprising of six generation companies (GENCOs), one national transmission company (TRANSCO), and eleven distribution companies (DISCOs) (see Fig 2.9).

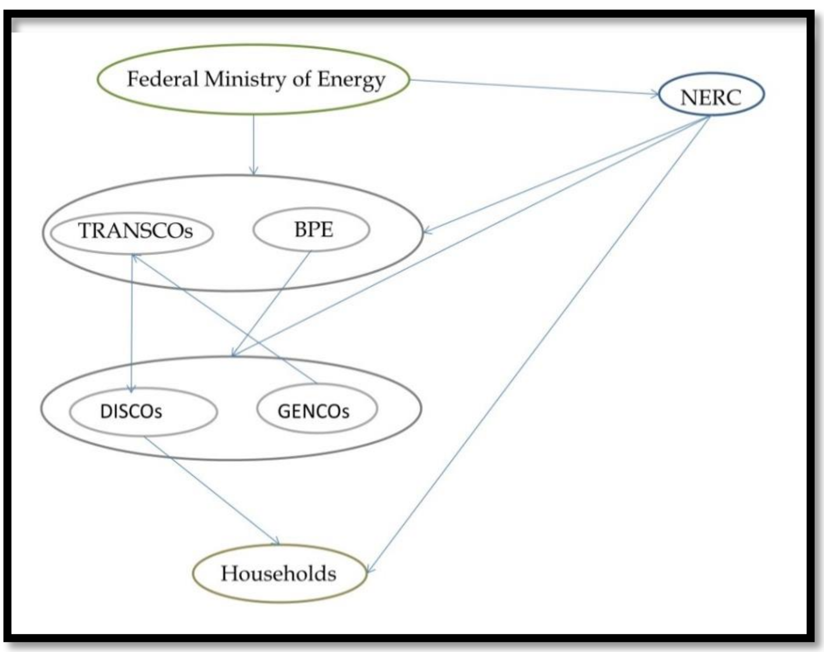

Figure 2.9 Nigeria's electricity regime (2005 – 2013). *Source*: Author

In September 2013, Nigeria made the move from a vertically integrated public utility to a mostly privately owned unbundled electricity system by the dissolution of PHCN. However, the Nigerian government still maintains its position as the dominant actor in the electrical sector and supervises the operator of the sole transmissions company (TRANSCO).

The deregulation of Nigeria's electricity sector is the first significant change in the country's electricity landscape since independence. It changes who the dominant actors are, the rules of the interactions between actors, and the goals of the sector.

Under the new regime, the federal ministry of energy has direct oversight over the Nigerian Electricity Regulatory Commission (NERC) as well as the Bureau of Public Enterprises (BPE) and the national transmission company (TRANSCO).

NERC is responsible for issuance of licenses for the electricity market participants (generation and distribution companies), developing industry standards for the transmission, generation, and distribution companies, as well as setting of tariffs (NERC, 2015). The BPE is tasked with the actual transaction activities required for the privatization and commercialization of public enterprises (BPE, 2013).

The TRANSCO makes the electricity generated by the GENCOs available for distribution to the DISCOs, which in turn make it available to the households. Transmission is currently done by PHCN and distributed through the 11 distribution companies: Abuja Electricity Distribution Plc, Benin Electricity Distribution Plc, Eko Electricity Distribution Plc, Enugu Electricity Distribution Plc, Ibadan Electricity Distribution Plc, Ikeja Electricity Distribution Plc, Jos Electricity Distribution Plc, Kaduna Electricity Distribution Plc, Kano Electricity Distribution Plc, Port Harcourt Electricity Distribution Plc, Yola Electricity Distribution Plc.

To date, the national government has been the primary regulatory body over the electricity industry. The jurisdiction of the different national parastatals over the electricity sector has been fuzzy at best. However, the Energy Corporation of Nigeria has had direct jurisdiction over PHCN as the electricity sector prepared for the transition to privatization.

2.6.2 The Multi-Year Tariff Order (MYTO)

Electricity in Nigeria has been a public welfare service and its pricing was historically subsidized and set by the previous national electrical power body, PHCN, subject to annual budgetary allocations. The methodologies used to ascertain the prices were unknown; however, the prices did not reflect income generated form the electricity sector (NERC, 2007) and are some of the lowest in sub-Saharan Africa (Table 2.2).

Table 2.2 Electricity pricing across select sub-Saharan African countries (c/kWh)

	Chad	Niger	Cameroun	Benin	Ghana	Nigeria
Social Tariff (100kWh/month)	11.07	16.85	17.33	21.60	9.41	1.58
Residential Tariff (600kWh/month)	25.60	16.85	19.10	24.51	12.92	9.68
Commercial Tariff (1800kWh/month)	26.75	20.52	23.55	24.00	21.92	9.66

Pricing of electricity prior to the first MYTO in 2008 was ₦6/kWh ($0.048/kWh USD[3]), which did not reflect the actual cost of electricity at ₦11.26/kWh ($0.09/kWh USD). More so because of low generation capacity, with the basic 1000W generator, the average consumer pays almost twice the actual cost of generated electricity in self-generation at ₦22/kWh ($0.13/kWh USD) (NERC, 2007).

In 2008, the first tariffs were set by the Nigerian Electricity Regulatory Commission (NERC) via a multi-year tariff order (MYTO) that was adjusted annually to reflect changes

[3] Adjusted for 2008 exchange rates.

in inflation, exchange rate, and gas prices (NERC, 2007). It set tariffs for the next five years while providing a 15-year projection for the evolution of tariffs with time. The tariffs were gradually increased from ₦6/kWh ($0.048/kWh USD) in 2008, to ₦10/kWh ($0.067/kWh USD) in 2011 with decreasing subsidy to make up for the actual cost of electricity. In its first iteration, the MYTO did not factor in other sources of generation fuel other than natural gas, as well as the difference in conditions that the new GENCOs might face (Bello, 2013). This deficiency was corrected in the next MYTO which was designed for 2012 to 2017. This new structure also created consumer classes based on maximum monthly electricity consumption levels.

The new MYTO also stipulates the tariff pricing in the post-privatization electricity landscape pending the increase of the number of generation companies in the market to truly make the market an open one.

2.7 Explaining the regimes through the institutional landscape

In the preceding sections, this paper discusses Nigeria's electricity landscape and the changes at the regime level. There have been minimal changes between the pre-colonial and post-independence rules and institutions in the sector.

The rules created to manage electricity consumption during the early nineteenth century have been carried forward such that they have shaped perceptions about the electricity artefacts (the physical infrastructure). Consequently the actions of the actors (government, market, civil society) are constrained by the technical possibilities, even though they themselves create these constraints.

It is simplistic to explain away this adverse relationship that brings about energy poverty as corruption. That term is itself a complex phenomenon created and perpetuated by the right confluence of circumstances: it might show that there are codified rules with absent sanction, but it does not explain why or how some rules are fixed while others are malleable.

This paper limits the discussion to those factors that impacted the energy landscape, namely: colonial governance type; ethnic heterogeneity resulting from social and cultural dislocation; and the new institutionalized dependence on public service.

2.7.1. Colonial governance history

There is consensus that colonialism has an impact on the long-term developmental trajectories of former nation states (Brown, 2000; Grier, 1999; Mahoney, 2003; Sokoloff & Engerman, 2000; Young, 1994). The most significant impact of colonial rule was the changes it brought to the social, economic, and political landscapes of the colonies. However, the success of development of the countries post-independence was dependent on the type of colonial rule enforced.

Scholarship on the colonial period indicates that colonies were ruled on the principle of colonial self-sufficiency (Young 1994, pp. 84). Thus each colonial power employed administrative strategies that were most efficient for resource extraction or in the case of southern African nation states, settlement. Resource extractive states are those colonial states created for the singular purpose of extracting resources rapidly; investments made in those states are limited to transportation of the resource and security (Acemoglu et al., 2001).

There were four types of colonial rule: *company rule* that focused on the exploitation of natural resources for investor profit with social and cultural dislocation created by the forced movement of people; *direct rule* focused on assimilation, removed local leadership from power using "divide and rule" tactics, and created social and cultural dislocation due to economic and labor policies (primarily practiced by the French, Belgian and Portuguese colonialists); *indirect rule* erroneously assumed all Africans belonged to tribes and delegated local "big men" as ruling figure heads in societies that never had such political structures. It created social and cultural dislocation due to economic and labor practices (primarily practiced by the British); and finally, *settler rule* with strong government systems protecting rights of settlers and infrastructural support for settler owned businesses, indigenous peoples were denied rights of political participation (primarily practiced in South Africa) (Khapova, p. 117).

Nigeria, as well as other British colonies, was ruled via indirect rule. Under this governance system, indigenous auxiliaries were needed to organize labor for the colonial economy, with a preference for younger men who had some knowledge of the official language (English or French). According to Geschiere (1993), the first generation of chiefs were young men who had worked in the colonial armies as soldiers, cooks, or porters. This was problematic in most of the African colonies because the indigenous governance norm was to appoint the elders as rulers. This was worse, still, for areas that were not accustomed to any form of centralized authority, with families living in autonomous family clans or villages.

It is important to note that the three regions that were amalgamated (the Northern protectorate, and the Southern protectorate consisting of the eastern and western geopolitical zones) have very different governance structures. The Northern protectorate was a structured state with clear jurisdictions in its hierarchy. It consisted of communities that were formerly part of Islamic empires, kingdoms, and caliphates for over five hundred years ("Katsina", 2015). Similarly, the western states in the Southern protectorates had belonged to empires and kingdoms for centuries ("Oyo", 2015). The monarchies were ruled by a hereditary line of *Obas*, a political system that still is in place today. Conversely, the eastern states of the Southern protectorates consisted of monarchies as well as traditionally stateless societies living in autonomous local communities ("Igbo", 2015). Stateless societies, such as the Igbos, do not have chiefs with the same broad political powers as those in the west or north.

The appointment of these "warrant chiefs", whose authority depended on their British warrants and local police, created a ruling class without legitimacy, a colonial legacy without traditional roots. These forms of governance were however essential for the success of local and regional colonial administration. According to Lord Lugard[4] (1922), native chiefs constitute an integral part of the colonial administration with well-defined duties that must overlap as little as possible with that of the British officers. The local chief "must understand that he has no right to place and power unless he renders his proper services to the state" (p. 203).

Secondly, these chiefs were given broad institutional powers with control over communal lands and local law enforcement, thus replacing indigenous systems and their checks and balances (Boone, 1994; Mamdani, 1996). These institutional powers enabled them to play administrators and local subjects against each other, maintaining considerable autonomy from each, and controlling information and resource flows between the colonial administration and the local population (Clapham, 1982; Reno, 1995).

These chiefs received a salary, but most of their livelihood was earned from the exaction of rents on their chiefdoms using the military power provided by their regional colonial authority. This created a system of decentralized autocracy and the mental model of leadership thus became one of rent-seeking due to the lack of legitimacy of the local chiefs.

[4] Lord Lugard was the British colonial governor-general of Nigeria from 1899 to 1906 (Khapoya, 1998).

By the 1960s much of sub-Saharan Africa was experiencing independence from the different colonial entities. At this time the indigenous leadership (both legitimate and illegitimate), business men with the attendant patronage networks, and most prominently, former military officers, emerged as the new political elite (Fukuyama, 2014; Obi, 2011). These new nation states and their political elites were familiar with only one political tradition - the colonial era autocratic government with a governor in charge of its bureaucracy and all industry directed at resource extraction (Sandbrook, 1986; Fukuyama, 2014).

This model of governance was quickly duplicated post-independence between 1960 and 1999: of the 180 changes in leadership in Africa, 101 of them took place through a military takeover or some other non-constitutional event (Goldsmith, 2001). Nigeria itself had six military coups spanning 30 years of dictatorships until democratic elections in 1999 (LeVan, 2014). Since the advent of democratic elections, little has changed in the country's political traditions – it is still primarily a resource extractive state and described to have experienced a democratic transition without a democratic transformation (Obi, 2011). According to Obi (2011), strong client-patron links still exist at all levels of public service. Also, attempts to spur contribution to national GDP from other sectors of society - manufacturing, agriculture, *etc* - are negligible; neither is there a long-term plan to create economic self-sufficiency of the individual states that make up the country. Continuing in the legacy of colonial governance, it is a country where 9 oil-producing states provide the financial resources to run all 36 states at the local and state levels, as well as the national government, rather than one in which each state exploits its individual resources for economic self-sufficiency.

Nation states like Nigeria that were created via fractioning of multiple tribal states with widely differing indigenous governance traditions to form one weakly integrated nation, governed via colonial indirect rule with ensuing post-colonial issues of legitimacy of leadership have been found to be more likely to be politically unstable, and have poor bureaucratic effectiveness and rule of law, controlling for other factors (Lange, 2004).

These factors were exacerbated by the ethnic heterogeneity of the newly created nation states.

2.7.2 Ethnic heterogeneity

While there was pre-existing ethnic and linguistic diversity, there was no regional concentration of caste or racial groups (as in India or the United States), giving an illusion of ethnic homogeneity. Thus in the efforts to create economies of scale and minimize bureaucratic costs, large states were drawn arbitrarily across indigenous tribal and linguistic groups, splitting them up across two or sometimes three colonial borders (Green, 2013). The consequence was the creation of new ethnic identities that today make up 43 percent of the average African state's population, making it the most fractionalized continent (Englebert et al. 2002, pp. 1096). Nigeria is the most fractionalized nation on the continent with over 250 ethnic identities (Omotosho, 2014).

Grabowski (2006) indicates that at independence, the new nation states were mainly dependent on the agricultural sector as the primary driver of the economy. It was also the largest industry in terms of employment. However, with the adoption of urban bias, i.e. the concentrating of public and social services at lower prices for urban residents than for rural residents, and agricultural policies that kept the prices of food down, the agricultural sector weakened and the ruling elite became increasingly dependent on the extractive industries.

To keep their hold on political power, the ruling elite strengthened their positions by relying on client-patron relationships, a phenomenon exacerbated by the degree of fractionalization in the more ethnically heterogeneous nation states.

There is a strong negative strong correlation between ethnic heterogeneity and the quality of institutions and economic growth (Alesina et al., 2003). Ethnic heterogeneity is strongly correlated with economic stagnation because it makes societies more likely to select socially suboptimal policies (Easterly, 1997).

Easterly (1997) found that ethnic heterogeneity (i) encouraged the adoption of policies that fostered rent-seeking and retarded economic and developmental growth and (ii) made it more difficult for groups to form consensus on promoting public goods.

Fractionalization leads to weak governance institutions as people seek a better life by capitalizing on private relationships (Bates, 2000). Kinsmen in the different levels of public service are expected to perform acts of patronage benefitting their kinship group (providing employment in the civil service, legally or illegally; granting preferential access to public sector resources outside of governmental regulation e.g. license to import specific goods, contracts to build infrastructure *etc*.). Padro i Miquel, (2007) found that fear of exclusion from patronage drives members of an ethnic group to support a ruler who is their kinsman even with evidence that the individual is interested in rent-extraction. In a highly heterogeneous society, this creates a system of uncoordinated bribe-takers in which each independent rent-taker fails to internalize the impact of their rent-seeking, leading to a total collapse of the system with more rents per unit of output and less output (Shleifer & Vishny, 1993).

In heterogeneous societies, relationships are organized along ethnic alliances, thus ethnic bias is self-sustaining. It is shaped by codes of conduct that reduce inter-ethnic interactions, described by Fafchamps (2004) as *statistical discrimination* and the *network effect* that retard economic and development growth.

Statistical discrimination describes discrimination based on belonging to a different ethnic group due to the high cost of gathering and evaluating information (i.e. discrimination based on stereotypes of the person's ethnic group: e.g. Batswana are lazy in civil service, Urhobos are cunning, Igbos are materialistic, *etc.*). Jellal and Zenou (2005) indicate that this kind of discrimination in the labor market exists in ethnically heterogeneous developing countries with employees from similar ethnic backgrounds as their employers having stability of income as opposed to the volatility of income experienced by employees from different ethnic backgrounds. This bias inhibits a vigorous economic environment, limiting recruitment of talent to the network of trusted kin and acquaintances rather than appropriately skilled employees in the electricity sector at all levels.

The *network effect* refers to the characteristic of market transactions in Africa involving multiple intermediaries linked by a chain of personal acquaintances. This leads to fragmented small homogenous markets, sustained through low labor mobility and creating high transaction costs in inter-regional domestic trade. The low labor mobility creates insufficient aggregation and thus lower division of labor, knowledge spillover, and higher costs of shared inputs (Hamaguchi, 2012). In essence knowledge-sharing is inhibited because of preference for relationships with others with whom there are shared social conventions and definitions even if there is minimal interest in the area of knowledge. Similar to statistical discrimination, the network effect ensures that the ruling elite establish hereditary claim on administrative offices via patron-client linkages rather than effective and qualified employees.

Both of these factors are endogenous variables that contribute to the dismal state of Nigeria's electricity sector infrastructure. Much like foreign aid NGOs that equate success with the number of projects completed rather than the longevity and viability of the individual projects, successive national government regimes emphasize construction of new facilities rather than funding the operations and maintenance of existing generation, distribution, and transmission networks. As aforementioned, funds for purchasing fuel or maintaining the physical electricity infrastructure are missing or non-existent thus undermining supply of, and access to electricity (Akinosho, 2013). The rationale for this can be attributed to perverse incentives in benchmarking: each administration desires a physical edifice that memorializes their time, and by extension, the impact of their kinship group, while in office.

As to the issue of maintenance culture in Nigeria, there is scant literature on the subject. It is however the theme of interest across a wide range of disciplines: from agriculture to publishing, telecommunications, fisheries and aquatic sciences, healthcare facilities management, and aviation, there is a marked absence of maintenance funding in annual budget allocation (Adegbulugbe et al., 2015; Eyitayo, 2011; Akinsanmi et al., 2013; Alhassan et al., 2012; Adenuga et al., 2007; Amara, 2009). In instances in which there is a budget, there is resistance to implementation of preventive maintenance activities either due to insufficient human capital or a breakdown in operational oversight. Maintenance culture in Nigeria is a rich subject that warrants further research but will not be explored in this paper.

2.7.3 Public service consumptionism

Colonialism created a legacy of dependence on the national government for public services through a confluence of factors.

First, in order to recruit and retain employees from colonial nations, there was a *status quo* of concentrating public goods and basic infrastructure such as water, electricity, and sewage around residential and administrative areas of local administration. This legacy of government intervention was viewed as an attribute of modernization and was inherited by the emerging political elite, in addition to western housing and physical infrastructure, creating a skewed allocation of public goods, an urban bias, that is still pervasive today (Ichoku et al., 2012).

This engendered the mental model of public service and public goods as the exclusive purview of civil servants in the public sector, and a dependence on the state for schools, hospitals, roads, electricity, and other infrastructure: 100% of participants surveyed indicated that it was the responsibility of the national government, not the state, or local government, or cooperatives, or community groups, to provide these public benefits. Thus expectations of public service as a source of affluence and influence are pervasive.

Secondly, spurred on by the acceleration of statehood continent-wide, the rapid urbanization due to the presence of large natural resource deposits, and the dilution of traditional governance restraints due to the amalgamation of these disparate nation states and tribes, the new political elites sought legitimacy in neopatrimonialism (Andreski, 1968). Neopatrimonialism, the use of state resources to secure loyalty of clients, centralizes power around the leadership (local or national) (Taylor, 2008), and much like ethnic fractionalization, weakens the effectiveness of government institutions, reducing the quality of governance, and thus the choice of economic policies.

Englebert (2000) found that the more legitimate the national government was – legitimacy defined as similarity between the existing political leadership, pre-colonial political systems, and norms of political authority - the greater the quality of its governance institutions. This legitimacy is tied to factors such as similarity of scale of governance pre- and post-colonialism (Olson, 1987) as well as lineage (e.g. descendants of pre-colonial ruling families) (Englebert, 2000). Thus the more fractionalized a country is, as most countries in sub-Saharan Africa post amalgamation, the less likely the view of legitimacy of the president. The president is often referred to in the third person rather than the possessive first person: he is "the president", not "our president" if he does not come from the same tribal group. It must also be noted that in countries with high degrees of heterogeneity like Nigeria, there is some acceptance of neopatrimonialism: it is expected that kinsmen in positions of influence (i.e. upper level public service) perform acts of patronage benefitting their kinship group, and making this a new kind of norm. This kind of patronism further exacerbates the perception and belief that state resources are inexhaustible, belong to no one and are controlled by "the government", an amorphous all-powerful wealthy entity. There is a resulting tragedy of the commons with regards to public goods such as roads and natural resources (forestry, water bodies, etc.) that is pervasive and accepted.

These mental models, these deeply ingrained assumptions and generalizations that influence our understanding of the world and how we act, helped to create the current state of energy poverty which is most visible through its symptoms: conflict, lack of security, social inequity, pervasive poverty, and environmental degradation.

2.8 Conclusion

The new waves of privatization and free market preference in public goods supply and administration sweeping the developing world do not explicitly have poverty alleviation, and in the case of electricity systems, energy-poverty alleviation as their goal. There is an assumption that an increase in generation and distribution capacity implies an energy-secure population or universal access. This does not guard against perverse outcomes from the well-intentioned policies and, in the Nigerian electricity system, raises a few issues.

First, this study shows that the historic colonial governance legacy has created mental models about governance as a facilitator for resource extractive activities. The governance institutions outside of oil and gas production and exportation are weak: the last national energy policy was drafted in 2003 with emphasis on energy production and resource exportation. Language on strategies for regulation, transparency, and enforcement in the energy sector were non-existent, making changes in the deeply ingrained energy governance institutions less likely; the only difference now in the energy landscape is the actors.

Also, studies show that because utilities like the electricity sector function most efficiently as monopolies, incumbent power generating and distributing companies have the potential to derail reforms by using their position to foreclose markets, deter entry, and abuse competitors and suppliers (Boscheck, 1994). In the current set up of Nigeria's electricity sector, NERC is responsible for issuing of licenses and specifying industry standards. However, as the sector matures and incumbent power companies dominate the different geographic regions, checks and balances would need to be instituted to keep the marketplace truly open.

Secondly, within the context of a socio-technical system, with the actors' (in this case the political elite) behaviors molded by long-term path-dependency, what measures are in place to address deeply ingrained norms? Neopatrimonialism is linked to legitimacy of governance as well as fractionalization. Without checks and balances to disincentivise the preference for suboptimal policies and dependence on kinship networks, the incidences of patronage will continue to sabotage progress even with codified rules that eschew graft. This is a complex issue tied to the lack of a cohesive and inclusive national narrative.

Third, landscape change is a slow continuous process. The socio-technical landscape encompasses heterogeneous factors such as fuel prices, economic growth, conflict, political coalitions, cultural and normative values, as well as environmental problems (Geels, 2002). Changes within the electricity system are determined by the context of these broader external factors which impact the institutions within the regime. Thus change should be expected to occur more slowly at the landscape level, spurred by incremental changes within the regime.

Finally, rural electrification is best addressed by distributed generation. However, the technologies that are used must have local buy-in. It is unrealistic to expect that generation plants whose parts can only be sourced abroad, and for whom there is no local human capital (trained technicians), will be sustainable. The success of rural electrification would depend on technologies that indigenous technicians are relatively comfortable with (hydro, biogas, etc.) and for which parts can be sourced locally (for instance reverse-engineering automobile alternators to serve as micro-windmill turbines). This must be true at the level of development of the local economy so as to stimulate industry towards more technologically mature systems.

This paper provides the first step of understanding the historical context of the electricity landscape in Nigeria. At present, Nigeria's political landscape is a dynamic system with an unclear future which makes it a rich subject for future work on feasible governance institutional changes.

Bibliography

1. Abdullah, S., & Markandya, A. (2012). Rural electrification programmes in kenya: Policy conclusions from a valuation study. *Energy for Sustainable Development, 16*(1), 103-110. doi:10.1016/j.esd.2011.10.007.

2. Acemoglu, D., S. Johnson and J. A. Robinson (2001), The Colonial Origins of Comparative Development: An Empirical Investigation', *American Economic Review*, 91,1369–1401.

3. Adam Smith International. (2013, September 23). The light is getting brighter in Nigeria. The Guardian. Retrieved from http://www.theguardian.com/global-development-professionals-network/adam-smith-international-partner-zone/nigeria-power-electricity-africa.

4. Adegbulugbe, T. A., Bello, R. S., & Oniyire, S. O. (2015). Investigation into industrial generator maintenance culture in agro-based industries in ibadan, south-west nigeria.*Agricultural Engineering International: CIGR Journal, 17*(2), 39-44. Retrieved from www.scopus.com

5. Adenuga, O. A., Odusami, K. T., & Faremi, J. O. (2007). Assessment of factors affecting maintenance management of public hospital buildings in lagos state, nigeria. Paper presented at the *Construction and Building Research Conference of the Royal Institution of Chartered Surveyors, COBRA 2007,*

6. Adeyeri, M. K., Kareem, B., Ayodeji, S. P., & Emovon, I. (2011). Dynamic maintenance strategy, the panacea to materials wastage from machinery. Paper presented at the*Proceedings of the World Congress on Engineering 2011, WCE 2011, , 1* 691-695. Retrieved from www.scopus.com

7. Ahenda, A.O. (2015). *A shift in mental models processing: A systems approach*. In M, Muchie, V. Gumede, P. Lukhele-Olorunju (Eds.), *Unite or Perish: Africa Fifty Years after the Founding of the OAU* (pp. 163-175).Africa Institute of South Africa.

8. Ahlborg, H., & Sjöstedt, M. (2015). Small-scale hydropower in africa: Socio-technical designs for renewable energy in tanzanian villages. *Energy Research and Social Science, 5*, 20-33. doi:10.1016/j.erss.2014.12.017

9. Ake, C. (1996). *Democracy and Development in Africa*. Washington, DC: The Brookings Institution.

10. Akinbulire, T. O., Oluseyi, P. O., & Babatunde, O. M. (2014). Techno-economic and environmental evaluation of demand side management techniques for rural electrification in ibadan, nigeria. *International Journal of Energy and Environmental Engineering*, *5*(4), 375-385. doi:10.1007/s40095-014-0132-2.

11. Akinosho, T. (2013, October 22). Nigeria Commissions Thermal Plants Without Fuel Supply. Africa oil and gas report. Retrieved from

http://africaoilgasreport.com/2013/10/gas-monetization/nigeria-commissions-thermal-plants-without-fuel-supply/

12. Akinsanmi, O., Ekundayo, K. R., & Okorie, P. U. (2013). R*eliability assessment of an electronic system: A case study of nokia N1650 mobile phone charger in zaria, nigeria*doi:10.4028/www.scientific.net/AMR.824.170

13. Alamba, S. (2011, July 22). *Nigeria Power employee works on a tangle of lines.* [digital image]. Retrieved from http://www.voanews.com/content/nigeria_power_capacity_poverty_oil_electrical_access/1447395.html

14. Alesina, Alberto, and Enrico Spolaore. (1997). On the Number and Size of Nations. *Quarterly Journal of Economics*, 112: 1027-1056.

15. Alesina, Alberto, et al. *Public Goods and Ethnic Divisions*. Harvard University and World Bank mimeo, March 1997.

16. Alhassan, D. A., Ahmed, Y. B., & Ugwu, F. C. (2012). Privatization: A policy to transform and increase the production capacity of fish in nigeria fish industries. *Journal of Fisheries and Aquatic Science, 8*(1 SPL. ISS.), 26-29. doi:10.39231jfas.2013.26.29

17. Allot, A. N. (1978). Nigeria: Land Use Decree, 1978. *Journal of African Law*, 22(2): 136-160.

18. Amara, J. I. (2009). Mixed culture in maintenance facilities in nigeria. Paper presented at the *Proceedings of the Flight Safety Foundation Annual International Air Safety Seminar, International Federation of Airworthiness International Conference, and the International Air Transport Association, , 1* 589-619. Retrieved from www.scopus.com

19. Andreski, S. (1968).*The African Predicament*, London: Michael & Joseph, 1968.

20. Awofeso, N. (2011). Generator diesel exhaust: A major hazard to health and the environment in nigeria. *American Journal of Respiratory and Critical Care Medicine, 183*(10), 1437.

21. B.K. Sovacool. (2014). What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. *Energy Res Soc Sci*, 1 pp. 1–29

22. Basedau, M., & Lay, J. (2005). Conceptualising the 'Resource Curse'in Sub-Saharan Africa: Affected Areas and Transmission Channels. *Resource Politics in Sub-Saharan Africa*, 9-24.

23. Bates, R. H. (2000). Ethnicity and development in Africa: A reappraisal. *American Economic Review* 90: 131-34.

24. Bello, S.L. (2013). Evaluating the Methodology of Setting Electricity Prices in Nigeria. *International Association for Energy Economics.*4th Quarter, 33-34.

25. Blum, A. L., & Langley, P. (1997). Selection of relevant features and examples in machine learning. *Artificial Intelligence, 97*(1-2), 245-271.

26. Boone, C. (1994). *States and ruling classes in postcolonial Africa: the enduring contradictions of power.* In J. Migdal, A. Kohli, & V. Shue (Eds.), *State power and social forces: domination*

and transformation in the Third World (pp. 108–139). New York: Cambridge University Press.

27. Brown, D. (2000). Democracy, colonization, and human capital in sub-Saharan Africa. *Studies in Comparative International Development*, 35(1), 20–40.

28. Büscher, B. (2009). Connecting political economies of energy in south africa. *Energy Policy, 37*(10), 3951-3958. doi:10.1016/j.enpol.2009.04.041

29. Caselli, F., Cunningham, T. (2007). Political decision making in resource abundant countries, Paper prepared for the OxCarre launch conference, December 2007.

30. Chidebell-Emordi, C. (2015). The African electricity deficit: Computing the minimum energy poverty line using field research in urban Nigeria. *Energy Research and Social Science, 5*, 9-19. doi:10.1016/j.erss.2014.12.011

31. Clapham, C. (1982). *The politics of failure: Clientelism, political instability and national integration in Liberia and Sierra Leone.* In C. Clapham (Ed.), Private patronage and public power (pp. 71–97). New York: St. Martin's Press.

32. Connors, W. (2009, April 25). Nigeria Moves to Address Chronic Power Outages. *The Wall Street Journal.* Retrieved from http://www.wsj.com/articles/SB124062314911155519

33. Coutard O, Guy S. (2007). STS and the city: politics and practices of hope. *Sci Technol Hum Values*; 32(6):713–34.

34. Dagoumasa,A., Kitsios, K. (2014). Assessing the impact of the economic crisis on energy poverty in Greece. *Sustainable Cities and Society,* 13: 267–278.

35. Damania, R., Bulte, E. (2003). Resources for sale: Corruption, democracy and the natural resource curse, Discussion Paper no. 0320, Centre for International Economic Studies, University of Adelaide.

36. Dibue, J.I. (2006*). Modernization and the Crisis of Development in Africa: The Nigerian Experience*. Hampshire: Ashgate Publishing Company.

37. Dike, A. (1983). Land Tenure System in Igboland. *International Review of Ethnology and Linguistics. Anthropos,* 78: 853-871.

38. E.M. Akpabio & N.S. Akpan. (2010). Power supply and environmental sustainability in the University of Uyo: an agenda for full-blown research in Nigeria. *Journal of African Studies Development*, 2(6): 132–143.

39. Eme Ichoku, H., Fonta, W. M., & Ataguba, J. E. (2013). Political economy and history: Making sense of health financing in sub-saharan africa. *Journal of International Development, 25*(3), 297-309. doi:10.1002/jid.2842

40. Englebert P, Tarango S and Carter M (2002) Dismemberment and suffocation: A contribution to the debate on African boundaries. *Comparative Political Studies* 35(10): 1093–118.

41. Englebert, P. (2000). Pre-colonial institutions, post-colonial states, and economic development in tropical Africa. *Political Research Quarterly* 53, 7 – 36.

42. Epstein, M. (1913). *Statemans Year Book*. London: Macmillian and Co., 64th Ed, 1949. Available online: http://catalog.hathitrust.org/Record/008883627

43. Eyitayo, S. A. (2011). Book, technology and infrastructural development: What the future holds for the book industry in nigeria. *Publishing Research Quarterly, 27*(3), 277-287. doi:10.1007/s12109-011-9230-7

44. Fafchamps, M. (2004). *Market institutions in Sub-Saharan Africa*. Cambridge, MA: MIT Press.

45. Faruqui A, Sergici S, and Sharif A. (2010). The impact of informational feedback on energy consumption – a survey of the experimental evidence. *Energy,* 35:1598–608.

46. Foster, J. (2005). From simplistic to complex systems in economics. *Cambridge Journal of Economics*, 29: 873-892.

47. Fukuyama, F., & Fukuyama, F. (2014). Political order and political decay: From the industrial revolution to the globalization of democracy.

48. Garside, B. (2011, February 24). Power and politics in Nigeria. *International Institute for Environment and Development*. Retrieved from http://www.iied.org/power-politics-nigeria

49. Garside, B. (2012, January 27). Privatising Nigeria's power sector. *International Institute for Environment and Development*. Retrieved from http://www.iied.org/privatising-nigeria-s-power-sector

50. Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy, 33*(6-7), 897-920. doi:10.1016/j.respol.2004.01.015

51. Geschiere, P. (1993). Chiefs and Colonial Rule in Cameroon: Inventing Chieftaincy, French and British Style . *Africa: Journal of the International African Institute, 63(* 2), 151-175.

52. Goldsmith, A. A. (2001). Risk, rule, and reason in Africa: Leadership in Africa. *Public Administration and Development*, 21(2), 77-87.

53. Goldthau, A. (2014). Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research and Social Science, 1*, 134-140. doi:10.1016/j.erss.2014.02.009.

54. Grabowski, R. (2006). Political development, agriculture, and ethnic divisions: An african perspective. *African Development Review, 18*(2), 163-182. doi:10.1111/j.1467-8268.2006.00137.x

55. Green, E. (2013). Explaining african ethnic diversity. *International Political Science Review, 34*(3), 235-253. doi:10.1177/0192512112455075

56. Grier, R. (1999). Colonial legacies and economic growth. *Public Choice*, 98(3–4), 317–335.

57. Groh, S. (2014). The role of energy in development processes—The energy poverty penalty: Case study of Arequipa (Peru). *Energy for Sustainable Development,* 18: 83–99.

58. Gunningham, N. (2013). Managing the energy trilemma: The case of Indonesia. *Energy Policy*, 54: 184–193.

59. Hall, D. (2007). Energy privatization and reform in East Africa. Public Services International Research Unit (PSIRU), University of Greenwich, 12 January.

60. Hamaguchi, N. (2012). *Evidence from spatial correlation of poverty and income in kenya* doi:10.1017/CBO9781139198998.011

61. Hino, H. (2012). *Ethnic diversity and economic instability in Africa: Interdisciplinary perspectives*. Cambridge, UK ; New York: Cambridge University Press.

62. Hughes, T.P. (1987). *The evolution of large technological systems*. In T.P. Hughes, W.E. Bijker, T.P. Hughes, T.J. Pinch (Eds.), *The social construction of technological systems: new directions in the sociology and history of technology,* (pp. 51–82)MIT Press, Cambridge, MA

63. Ibuot, U. (2014, October 9). Nigeria: Why We Stopped Distribution of Pre-Paid Meters - Eko Disco. *Vanguard*. Retrieved from http://allafrica.com/stories/201410090384.html.

64. Jellal, M, & Zenou, Y. (2005). Ethnic diversity, market structure and risk sharing in developing countries. CEPR Discussion Papers 5366.

65. Joseph, D. (2012). Nigerians Still Await Golden Era Of Uninterrupted Power Supply. Retrieved from http://naijalife.freehostia.com/mag/?p=4378

66. Joseph, I.O.O. (2014). Issues and challenges in the Privatized Power Sector in Nigeria. *Journal of Sustainable Development Studies, 6*(1), 161-174.

67. Kahn, A.E. (1989). *The Economics of Regulation: Principles and Institutions*. Cambridge, Mass: The MIT Press.

68. Kamalapur, G. D., Udaykumar, R. Y., & Karajgi, S. B. (2008). People's participation in rural electrification -A successful case. Paper presented at the Proceedings - *1st International Conference on Emerging Trends in Engineering and Technology, ICETET 2008*, 945-949. doi:10.1109/ICETET.2008.226

69. Kamp, L. M., & Vanheule, L. F. I. (2015). Review of the small wind turbine sector in kenya: Status and bottlenecks for growth. *Renewable and Sustainable Energy Reviews, 49*, 470-480. doi:10.1016/j.rser.2015.04.082

70. Kaserman, D.L., and Mayo, J.W. (1991). The measurement of vertical economics and the efficient structure of the electric utility industry. *The Journal of Industrial Economics*, 483-502.

71. Keating, M. F. (2006). *Global best practice(s) and electricity sector reform in Uganda.* Working Paper. Coventry: University of Warwick. Centre for the Study of Globalisation and Regionalisation. Working papers (University of Warwick. Centre for the Study of Globalisation and Regionalisation) (No.192)

72. Khapoya, V.B. *The African Experience: An Introduction*. San Francisco: Peachpit Press, 2012.

73. Le Billion, P. (2005). The resource curse. *Adelphi Papers* 45 (373), 11–27.

74. LeVan, A. C. (2014). Analytic authoritarianism and Nigeria. *Commonwealth and Comparative Politics*, 52(2), 212-231. doi:10.1080/14662043.2014.892722

75. Lugard, F. (1922). The dual mandate in British tropical Africa. London: W. Blackwood and Sons.

76. Macartan, H et al. (2007). *Escaping the Resource Curse*. New York: Columbia University Press.

77. Mahoney, J. (2003). Long-run development and the legacy of colonialism in Spanish America. *American Journal of Sociology*, 109(1), 50–106.

78. Makan, A. (2013, October 10). Nigerian natural gas waiting to be tapped. *Financial Times*. Retrieved from http://www.ft.com/intl/cms/s/0/656c3abe-2440-11e3-a8f7-00144feab7de.html#axzz3QntVOE75

79. Mamdani, M. (1996). *Citizen and subject*. Princeton, NJ: Princeton University Press.

80. Mehlum, H., Moene, K., and Torvik. R. (2006). Institutions and the resource curse. *The Economic Journal*, 116:1–20.

81. Mishra, T. (2015). *Characterizing Energy Poverty: Implications for Energy Access Policies* In B. Sudhakara Reddy, S. Ulgiati (Eds.), *Energy Security and Development: The Global Context and Indian Perspectives* (pp 321 – 329). India: Springer.

82. Morse, Janice, M. (2000). Determining sample size. *Qualitative Health Research*, *10*(1), 3-5.

83. Nhete, T.D. (2007). Electricity sector reform in Mozambique: a projection into the poverty and social impacts. *Journal of Cleaner Production*, 15: 190-202.

84. NNPC. 2015. The Nigerian National Petroleum Corporation Group.

85. Nussbaumer, P., Bazilian, M., & Modi, V. (2012). Measuring energy poverty: Focusing on what matters. *Renewable and Sustainable Energy Reviews, 16*(1), 231-243. doi:10.1016/j.rser.2011.07.150

86. Nwokpoku, J. (2014, October 14). Nigeria needs 6.5m pre-paid meters in five years — Onyema. *Vanguard Nigeria*. Retrieved from: http://www.vanguardngr.com/2014/10/nigeria-needs-6-5m-pre-paid-meters-five-years-onyema/

87. Obi, C. (2013). Taking back our democracy? the trials and travails of nigerian elections since 1999 doi:10.4324/9780203718742

88. Obi, S.N.C. (1963). *The Ibo law of property*. London: Butterworths.

89. O'Dell, K., Peters, S., & Wharton, K. (2014). Women, energy, and economic empowerment: Applying a gender lens to amplify the impact of energy. Paper presented at the *World Energy Engineering Congress, WEEC 2014,* 1200-1211.

90. Ogumwike, F.O. et al. (2014). Household Energy Use and Determinants: Evidence from Nigeria. *International Journal of Energy Economics and Policy*, 4(2): 248-262.

91. Okoro, O.I, & Chikuni, E. (2007). Power sector reforms in Nigeria: opportunities and challenges. *Journal of Energy in Southern Africa*, 18(3): 52-57.

92. Olukoju, A. (n.d.) *Infrastructure development and urban facilities in Lagos, 1861-2000*. Retrieved from http://books.openedition.org/ifra/829

93. Omotosho, M. (2014). Managing religious conflicts in nigeria: The inter-religious mediation peace strategy. *Africa Development, 39*(2), 133-152.

94. Onyeji et al. (2012). Contextualizing electricity access in sub-Saharan Africa. *Energy for Sustainable Development* 16: 520–527.

95. Oparaocha, S., & Dutta, S. (2011). Gender and energy for sustainable development. *Current Opinion in Environmental Sustainability, 3*(4), 265-271. doi:10.1016/j.cosust.2011.07.003

96. Oseni, M.O., 2012. Households' access to electricity and energy consumption pattern in Nigeria. *Renewable and Sustainable Energy Reviews*, 16, 990–995.

97. Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, **2**:15.

98. Pachauri, S., Spreng, D., 2004. Energy use and energy access in relation to poverty. *Econ and Pol Wkly* 39 (3).

99. Padr´o i Miquel, G. (2007). The Control of Politicians in Divided Societies: The Politics of Fear. *The Review of Economic Studies* 74(4): 1259–1274.

100. Pegg, S. (2010). Is there a Dutch disease in Botswana. *Resource Policy 35*, 14–19.

101. Persson, T. et al. (1997). Separation of Powers and Accountability. *Quarterly Journal of Economics*, 112: 1163-1202.

102. Quah, J. S. T. (2010). *Chapter 11: Public administration Singapore-style* doi:10.1108/S0732-1317(2010)0000019016

103. Reno, W. *Corruption and state politics in Sierra Leone*. New York: Cambridge University Press. 1995.

104. Rip, A., Kemp, R. (1998). Technological change. In: Rayner, S., Malone, E.L. (Eds), *Human Choice and Climate Change*, Vol.2. Battelle Press, Columbus, OH, pp. 327–399.

105. Ross, M.L. (1999). The political economy of the resource curse. *World Politics* 51 (2), 297–322.

106. Shleifer, Andrei, and Robert Vishny. (1993). Corruption. *Quarterly Journal of Economics*, 108: 599-617.

107. Sokoloff, K., & Engerman, S. (2000). Institutions, factor endowments, and paths of development in the New World. *Journal of Economic Perspectives*, 14(3), 217–232.

108. Sonibare, J. A., Adeniran, J. A., Fakinle, B. S., Latinwo, I. O., Jimoda, L. A., & Olu-Arotiowa, O. A. (2014). Ambient noise from off-grid diesel engines electric power generators in an urban environment. *Management of Environmental Quality, 25*(2), 186-199. doi:10.1108/MEQ-12-2012-0078

109. Sovacool, B. K. (2013). Confronting energy poverty behind the bamboo curtain: A review of challenges and solutions for Myanmar (Burma). *Energy for Sustainable Development* 17: 305–314.

110. Sovacool, B.K. et al. (2011). Halting hydro: A review of the socio-technical barriers to hydroelectric power plants in Nepal. *Energy*, 36(5): 3468–3476.

111. Stevens, P., Dietsche, E. (2008). Resource curse: an analysis of causes, experiences and possible ways forward. *Energy Policy*, 36: 56–65.

112. Sudhakara Reddy, B., & Nathan, H. S. K. (2013). Energy in the development strategy of indian households - the missing half. *Renewable and Sustainable Energy Reviews, 18*, 203-210. doi:10.1016/j.rser.2012.10.023

113. Sutherland, L., Peter, S., & Zagata, L. (2015). Conceptualising multi-regime interactions: The role of the agriculture sector in renewable energy transitions. *Research Policy, 44*(8), 1543-1554. doi:10.1016/j.respol.2015.05.013

114. T.P. Hughes. (1983). *Network of power: electrification in Western society, 1880–1930*. Johns Hopkins University Press, Baltimore

115. Ulsrud, K., Winther, T., Palit, D., & Rohracher, H. (2015). Village-level solar power in africa: Accelerating access to electricity services through a socio-technical design in kenya. *Energy Research and Social Science, 5*, 34-44. doi:10.1016/j.erss.2014.12.009

116. UNDP. 2007. Access to energy and human development. Human Development Report 2007/2008, United Nations Development Program Human Development Report Office Occasional Paper.

117. Unruh, G.C. (2000). Understanding carbon lock-in. *Energy Policy*, 28:817–30.

118. Van der Ploeg, F., & Poelhekke, S. (2009). Volatility and the natural resource curse. *Oxford economic papers*, gpp027.

119. van der Vleuten, E., & Raven, R. (2006). Lock-in and change: Distributed generation in denmark in a long-term perspective. *Energy Policy, 34*(18), 3739-3748. doi:10.1016/j.enpol.2005.08.016

120. Watts, M. (2010). *Curse of the Black Gold: 50 Years of Oil in the Niger Delta*. New York: Power House Books.

121. Weller, S. C., and Romney, A. K.,(Eds). (1988). *Systematic data collection*. Sage, Thousand Oakes, California, USA.

122. Williams, N. J., Jaramillo, P., Taneja, J., & Ustun, T. S. (2015). Enabling private sector investment in microgrid-based rural electrification in developing countries: A review. *Renewable and Sustainable Energy Reviews, 52,* 1268-1281. doi:10.1016/j.rser.2015.07.153

123. Young, C. (1994). *The African colonial state in comparative perspective*. New Haven, CT: Yale University Press.

124. Yuan, J., Xu, Y., Hu, Z., Yu, Z., Liu, J., Hu, Z., & Xu, M. (2012). Managing electric power system transition in china. *Renewable and Sustainable Energy Reviews, 16*(8), 5660-5677. doi:10.1016/j.rser.2012.05.046

CHAPTER 3

A CONTEXT-SPECIFIC MINIMUM ENERGY POVERTY LINE[5]

Abstract

Only half of the population of Nigeria has access to the electricity grid, and for those who have access, the supply of electricity is sporadic. Government estimates of electricity generation fail to give an accurate picture of electricity supply because they do not account for actual generation capacity as well as the siting of power plants predominantly in urban areas. This paper models average per capita electricity needs in three southwestern Nigerian states. The analysis is based on data on electrical power supply, appliances available in households, as well as intensity of use. Using a mixed-methods approach, we found that in urban southwestern Nigeria, per capita annual electrical energy consumption ranged between 230kWh to 2089kWh with an average of 463kWh as opposed to the 101.5kWh reported. There was very weak correlation between income, household size, and total household electricity consumption because most households lack steady income, and also because of the salary-hold phenomenon. Our model indicates that 1667 kWh annually is sufficient to provide for basic needs in an urban household. Electrification demand was also modeled for projected population growth to 2050.

---

[5] This portion of the dissertation has been published as "The African electricity deficit: Computing the minimum energy poverty line using field research in urban Nigeria" in *Energy Research & Social Sciences* journal; see Comprehensive Bibliography.

Executive Summary

This study proposes minimum electricity consumption per person annually based on field research in urban southwestern Nigeria. Urban southwestern Nigeria is the most affluent geopolitical zone of the country but it experiences a higher intensity of energy poverty because of the population density (i.e. the number of people per unit area is higher). Energy poverty is a term used to describe lack of access to adequate facilities for cooking, lighting, and electrical appliances. It is driven by low levels of electrification, poor or inadequate infrastructure and non-functional institutions, resulting in low economic development and other social issues.

Energy poverty intensity is expected to increase in sub-Saharan Africa with rural-urban migration is expected to increase over the next thirty years. This implies increasing stress on already stressed economic, environmental, and infrastructure resources in urban areas.

The proposed minimum electricity consumption of 1667 kWh per person annually is sufficient to provide for basic needs in an urban household. Electrification demand was also modeled for projected population growth depending on the household types.

3.1 Introduction

High levels of energy poverty in Africa are the driving force for African governments, donors and NGOs to increase electricity access in Africa, whether by fossil fuels or renewable energy, the subject of this Special Issue. Discussions about increasing wind energy (Mukasa, et al., 2015) and capacity-building through PhD engineering programs (Colenbrander, et al., 2015), among other issues identified in this Special Issue, must consider what we mean by energy poverty, a term that is usually defined in two main contexts: Western-Urban and Developing-Rural.

Western-Urban refers to industrialized states. In this context, energy poverty is defined in terms of social exclusion and material deprivation (Buzar, 2007; Healy, 2003; Sen, 1980; 1984; 1999). Energy poverty creates class distinctions and prevents ownership of luxury goods. This definition is often subjective and can vary widely within a small geographic area.

Developing–Rural is specific to rural areas in developing states. This definition of energy poverty is computed based on estimated energy required to provide electricity for lighting and energy-dense fuels for cooking in a rural locale (Sovacool et al., 2012; Parajuli, 2011; Goldemberg, 1998; Pachauri and Spreng, 2003; Foster et al., 2000). Almost by definition, world regions that are predominantly classified as energy poor are comprised mostly of developing states: this includes the 2.5 billion people who rely on biomass as cooking fuel, and the 1.6 billion people without access to electrification (Modi et al., 2005).

The population density of the energy poor is higher in urban than in rural areas, with the rural-to-urban migration trend expected to increase over the next 30 years. The energy poverty problem cannot be solved without first determining what per capita energy consumption is for urban areas in developing states (Cohen, 2006; UN-DESA, 2012).

The quantitative benchmarks that exist in the energy poverty literature are computed for the lack of access based on physiological needs and purchasing power for a fixed amount of basic needs in goods and services. For the Developing-Rural context, two minimal energy poverty lines have been computed: 1000W per capita (Goldemberg et al., 1985) and 300W per capita (Pachauri and Spreng, 2004) which convert to an annual consumption of 8765.8 kWh/cap and 2629.7 kWh/cap respectively. But in urban areas, people need more energy than just electricity for lighting and energy-dense cooking fuels; they also need energy to run cottage industries, which contribute 50% of GDP in sub-Saharan Africa (Meagher & Mohammed-Bello, 1996). Note that these electricity levels (Watts/cap) indicate the amount of electricity that needs to be supplied continuously per person and directly infer what the name-plate capacity for electricity generation should be for a given population. (Name-plate capacity is the maximum output of a generator or other electric power equipment under conditions set by the manufacturer). This is different from the total electricity consumed or produced per year, i.e. kWh/yr. For the purposes of simplicity, all subsequent electricity consumption units will be kWh.

The definition of basic needs varies by standard of living and regional locations; developing countries consume a fraction of what industrialized states consume per capita (Krugmann and Goldemberg, 1983). The definition depends on (1) the definition of well-being, (2) cultural understanding of harm or suffering, and (3) relative possibilities at the time.

The definition of well-being is subjective and tied to concepts like *functionings* (the various things a person may value doing and being) and *capabilities* (what a person is able to do). Functionings and capabilities may be cultural norms or codified laws. An example of something that is both a functioning and a capability is the ability of women to participate in community leadership (Sen 1984, 1994, 1997). A woman may be capable of leading but prevented from doing so by norms or laws. In such a case, the woman is effectively, but not actually, incapable of community leadership.

Secondly, cultural and individual understanding of harm or suffering varies from one place to another. For instance, in Nigeria it is quite common to see unaccompanied groups of three- to five-year olds walking for up to twenty minutes to and from their elementary schools on weekdays. This is a norm and has gone on for generations. Similarly, primary- and secondary-school students trek for up to an hour or more daily to and from school. Describing this time spent trekking in the hot sun as a hardship would only elicit blank stares among average Nigerians; it is the norm and not perceived as hardship, but rather as time for socializing.

Finally, the relative possibilities available at the time determine what would be considered a basic need within the given context. These possibilities depend on factors that influence energy consumption habits, such as geographical environment, income, production, culture, and hierarchy of energy choices.

The Goldemberg (1985) estimation of the annual minimal energy poverty line at 8765.8 kWh/cap is based on energy consumption between 1978 and 1982, with assumed non-commercial energy use of 3506 kWh/cap annually. It estimates in a year, 12,272 kWh, 14,901 kWh, and 15,778 kWh per-capita of electricity is required to satisfy basic human needs in Africa, Latin America, and Asia, respectively. These calculations are based on historical Energy-to-GNP correlations. Assumptions of residential energy-use levels are based on levels in Western Europe, Japan, Australia, New Zealand, and South Africa, all of which have very different climates, nutritional requirements, cultures, and energy choices. In addition to being based on aggregate data and very different energy consumption habits, this estimate is outdated.

The annual average of 4382.9 kWh/cap proposed by Pachauri and Spreng (2002) also aggregates energy consumption across urban and rural households, while incorporating direct and indirect energy consumed. Subsequent computations (Pachauri, 2004) calculate household energy consumption based on embedded energy content in household goods and services produced. This method limits determination of the amount of energy a region requires to provide for electrification and cooking fuel; these two requirements define the energy poverty line in developing states.

Existing energy poverty benchmarks are either outdated or based on non-contextual definitions of basic needs. I argue that a contextual energy poverty benchmark is needed for sub-Saharan Africa, which is home to half of the world's energy-poor populace (Pereira et al., 2011). Furthermore, a per capita energy benchmark should include electricity as a proxy for cooking fuel because of the danger of household fires in the sub-Saharan African region, as well as to simplify determination of energy profiles at different spatial scales.

Researchers have estimated the direct and indirect disaggregated household energy requirements for developing states such as India (Pachauri and Spreng, 2004; Chaurey et al., 2004) and South Africa (Davis, 1998). However, these estimations are few and difficult to find and, as mentioned above, they focus on rural locales. This article is the first published attempt to estimate and analyze disaggregated urban household electricity consumption and to model future electricity needs for an urban locale in a sub-Saharan African country.

I computed the minimal energy poverty line based on disaggregated household energy data collected in urban regions in Nigeria, using reported activity levels and household energy consumption. Using Nigeria as a case study, the model determines the per-capita minimal household end-use energy needs for urban sub-Saharan West Africa. Nigeria is significant in sub-Saharan Africa because it contains most of the region's urban settlements, thanks to its long-established and varied pre-colonial urban traditions (Potts, 2012). The levels of energy poverty in southwestern Nigeria are representative of other urban centers in sub-Saharan Africa, and as such, for urban energy poverty in the region as a whole. Also, the conversation on electricity supply in Nigeria, and most of sub-Saharan West Africa, is moving from favoring a centralized government-run institution to favoring decentralized providers in the form of independent power providers (IPPs) (The White House [Press Release], August 5, 2014; Karekezi & Kithyoma, 2002). While literature holds that the energy poor spend a significant proportion of their income on energy (Buzar, 2007; Sovacool, 2012), electricity prices are subsidized in Nigeria, and consumers need pay only a portion of their bill to continue receiving service. Energy poverty thus arises from inadequate supply rather than from limited consumer capacity to pay for electricity. To estimate how privatization of power generation will affect energy poverty in sub-Saharan Africa, we must first know how much power is supplied, what proportion of income the average household spends on energy, and how much power is consumed by households. This study provides that information for urban areas in southwest Nigeria.

3.2 Data and Methods

3.2.1 Study area

Southwestern (SW) Nigeria is one of the six geopolitical zones of the country. (See Fig 3.1 for a map of the geopolitical zones.) It consists of Oyo, Osun, Ogun, Ondo, Ekiti, and Lagos states. Though poverty levels in southwestern Nigeria are the lowest in the country (because Lagos is one of the wealthiest states in the country), the region is an appropriate zone of study because it experiences pervasive energy poverty (Sowunmi et al., 2012).

In addition, this region is the most politically and religiously stable part of the country, unlike the other five geopolitical zones, which are fraught with Boko Haram terrorism activities (NW, NE, and NC zones), kidnappings (SS, SE, and NC zones), and civil unrest (NC and SS zones).

Southwestern Nigeria lies in latitude 6°21'8" North and longitude 2°31'6" East (NPC, 1991). It has a tropical climate with wet and dry seasons, belonging to the Af (tropical rainforest climate) and Aw (tropical wet and dry or savannah climate) Köppen-Geiger climatic zones. Temperatures range from 21°C to 34°C (69.8°F to 93.2°F), and annual rainfall ranges between 150cm to 300cm (Faleyimu et al., 2010).

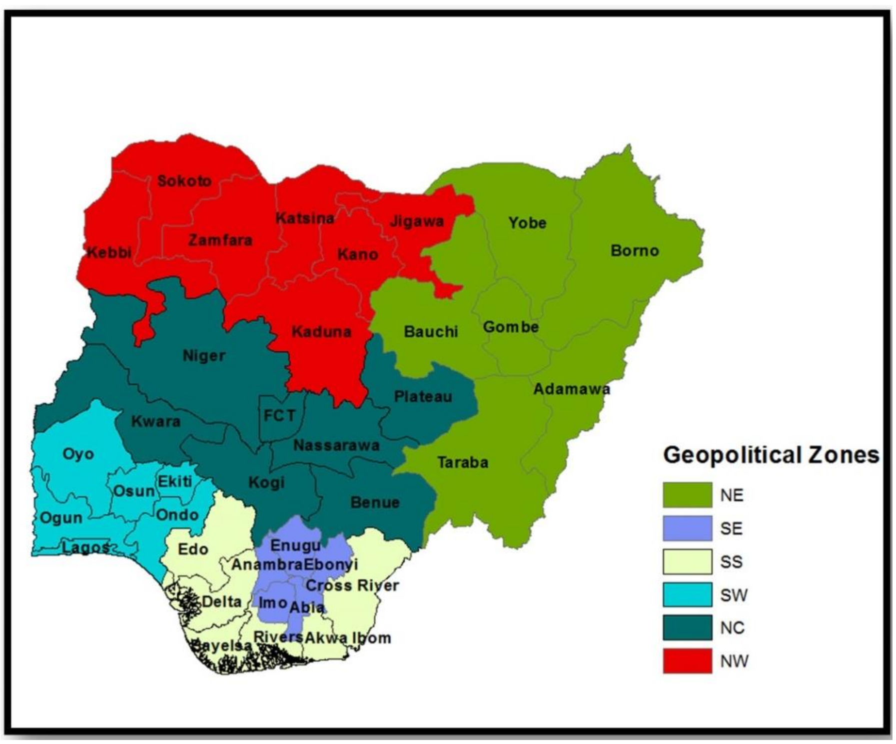

Figure 3.1 Nigeria's geopolitical landscape. *Source*: Author

The three states of Lagos, Oyo, and Osun are the most densely populated in the southwestern region, and also account for the largest rural-urban migration for that geopolitical zone. The study was conducted in urban areas in the three states. The survey sites were selected based on the definition of an urban area according to GoI's (2001) criteria: population greater than 5,000, population density of at least 400 persons/km^2, and the percentage of male workers engaged in non-agricultural sectors must be at least 75.

The data on energy consumption were collected in the Local Government Areas[6] that include the studied cities: Oshodi-Isolo in Lagos state (population density (pop. den.) 13,811 inhabitants per square kilometer (inh/km^2)), Ibadan-North in Oyo state (pop. den. 434 inh/km^2), and Ife-Central in Osun state (pop. den. 1506 inh/km^2).

Unlike some cities in developing and developed states in which affluent and poverty-stricken neighborhoods are geographically separated, in Nigeria it is typical to find extreme affluence next to abject poverty, both on the same electrical mains supply and therefore having the same power supply from the power company. For the purpose of simplicity, I have taken conservative estimates of power consumption for the refrigerator which cycles of and on, and I assume that households that have the same appliances would run them for the same length of time. Based on this assumption, while the total electricity consumption for a household is dependent on the appliances used, the intensity of use for each appliance is the same. This meant that sampling could be randomized in neighborhoods irrespective of the range of incomes represented by the diversity of household types. This randomization increased the validity of the data collected.

[6] A Local Government Area (LGA) is the third tier of the administrative structure in Nigeria, subject to the control of the state government (Asaju, 2010).

3.2.2 Data Collection

The literature on energy access initiatives in Nigeria provides no data on urban residents' access to, or consumption of, energy. Disaggregated data on energy consumption in general, and electricity consumption in particular, are non-existent in Nigeria, as is information on usage of energy and appliances, and data on transaction costs, hire-purchase arrangements (rental, leasing, collective purchase of energy infrastructure), and energy preferences. But all of this data is necessary to get an accurate picture of energy poverty (Prasad, 2002).

Prior to this study, data on energy use in urban cities had not been collected. This is in part because electrification initiatives have been focused on renewable energy for distributive generation in rural towns and villages (Bugaje, 2006; Akinbami, 1994; Ngala et al., 2007; Akinbami et al., 2001). To collect data on household end-use energy consumption, I used a convergent parallel design of the mixed-methods approach.. Both quantitative and qualitative data were collected simultaneously. The quantitative data was used to measure distinguishing characteristics, elemental properties, and empirical boundaries of the specified variables (Nau, 1995). Before integrating qualitative and quantitative data, each dataset was analyzed and interpreted separately according to the process described by Rosenberg et al. (2013).

Using convenience sampling, I surveyed 46 households in Oyo state, 49 households in Osun state, and 10 households in Lagos state for a total of 105 households (*n=105*), to collect data on household ownership of telecommunication devices, information and entertainment electronics, and electrical appliances. Households were selected randomly from sample neighborhoods located near large market areas. The survey was modeled after the Mimmi (2014) study designed to collect data on household energy use. That survey included questions on electricity expenses, household size, as well as the types of appliances used during discrete time periods, which enabled computation of energy intensity.

The survey was refined and tested for fit with the intended regression model. In order to administer it effectively, it was translated into Yoruba, the native language (Lloyd et al., 2002). Modifications needed to be carried out on the dataset before a regression model could be fitted. In principle, the regression analysis should be applied to all respondent households. In practice, however, certain observations had to be excluded because of the incompleteness of the data and missing values. Thus, households that did not report any expenditure on electricity were excluded. It is possible but quite unlikely that these households really had no electricity requirements. Other households were excluded because they were located in neighborhoods that represented outliers, for example, the neighborhood located next to military housing that had 75-100% electrification because high-ranking military officials resided there. While the example of this neighborhood is pertinent to understanding power dynamics in the provision of energy services, an examination of power dynamics is beyond the scope of this paper.

3.2.3 Data Analysis

The data collected were used to determine per capita end-use energy consumption; relationships between income, household energy expenditure, household demographics, and total household energy consumption; and to project consumption patterns in the future.

3.2.3.1 Computing electricity consumption

The direct electricity consumption per capita was computed by multiplying the power ratings for each of the appliances by the intensity of use and the number of hours of electricity supplied. This value was normalized by household and neighborhood characteristics to minimize the effect of variations in neighborhood supply. I computed

Table 3.1. Appliance ratings and intensity of use

Appliance	Power Rating (W)	Intensity of use (hrs/day)
Refrigerator[1]	1200	8
Air conditioner[2]	1100	7.28
Light bulbs	60	6
Fan	100	9
Microwave	1500	1
Iron	1100	0.5
Radio	30	8
LCD TV	213	8
Video Game Player	40	2
DVD	22	4
Well Pump (1/3-1HP)	1200	1
Laptop	250	8
Cell Phone	4	1
Oven	3000	2
Hot plate	1200	6
Blender	300	0.5
Water heater	479	2

[1]16 cu ft refrigerator/freezer. Refrigerators, although turned "on" all the time, actually cycle on and off as needed to maintain interior temperatures.
[2]A/C use of 16 hours on average weekdays, 11 hours on weekends during hot season (November to April).

intensity of use for each appliance as shown in Table 3.1. Because household sizes varied by location, per capita electricity consumption was computed based on average household sizes for each neighborhood and city.

With electricity consumption as a proxy for energy consumption, the per capita direct electricity requirement of households was used as a derived demand based on primary demand for other energy-consumptive goods such as electrical devices, corrected for intensity of use. Following standard economic theory, individuals were assumed to be utility maximizers subject to their budgetary constraints. The derived demand for total per capita electricity is a function of specific regional and demographic variables as represented in Equation 1.

$$E_i = f(A_i \delta_i \varphi_i) \tag{1}$$

where E_i refers to the total electricity consumption for the i^{th} person, A_i refers to the appliance power rating, δ_i is a variable correcting for intensity of use, and φ_i is a function of the geographic location variable.

The energy consumed per capita was computed as

$$E_{ik} = \varphi_k \frac{\sum_{i=1}^{j} A_i \delta_i}{(\sum_1^n S_k)/n_k} \tag{2}$$

where φ, S, and j are household demographic-variable coefficients. A description of each of the variables is provided in Table 3.2. The product $A_i \delta_i$ computes the daily power consumption for each appliance such that

$$\sum_{i=1}^{j} A_i \delta_i = A_1\delta_1 + A_2\delta_2 + A_3\delta_3 + \ldots + A_j\delta_j \; ; \tag{3}$$

where A_i is represented by the dummy variables as listed in Table 3.3.

Table 3.2: Variable definitions

Variable	Definition
E	Per capita electricity consumption (kWh)
i	i^{th} person
j	Number of appliances per household
A	Appliance rating (W)
δ	Intensity of use
ϕ	Power supply factor based on fraction of hours of grid electricity supply
S	Geographical variable for household size
n	Number of households per location
l	i^{th} household
k	k^{th} household geolocation

Table 3.3: Dummy variable definitions

Variable	Definition
gen	Dummy variable is 1 if the household owns a power generator and 0 otherwise.
Inv	Dummy variable is 1 if the household owns an inverter and 0 otherwise.
micro	Dummy variable is 1 if the household owns a microwave oven and 0 otherwise.
frig	Dummy variable is 1 if the household owns a refrigerator and 0 otherwise.
iron	Dummy variable is 1 if the household owns an iron and 0 otherwise.
fan	Dummy variable is 1 if the household owns a fan and 0 otherwise.
aircon	Dummy variable is 1 if the household owns an air conditioner unit and 0 otherwise.
radio	Dummy variable is 1 if the household owns a radio and 0 otherwise.
tv	Dummy variable is 1 if the household owns a television and 0 otherwise.
DVD	Dummy variable is 1 if the household owns a DVD player and 0 otherwise.
e_stove	Dummy variable is 1 if the household owns an electric cooking range and 0 otherwise.

From this data, an energy consumption map was created for the cities in the study. Next I conducted two analyses using statistical evaluation to determine which factors affect the variation in total per capita household electricity requirements. In the first analysis, household income was correlated to the total electrical energy consumption using tables and graphs. The second analysis was a linear regression fit with average per capita electricity consumption as the dependent variable and household size as the independent variable.

These analyses were adapted from the Specific Consumption Forecasting method as described by Bhattacharyya and Timilsina (2009). My model quantifies the relationship between household electricity consumption and economic variables, such as income and household dwelling characteristics, that might explain the variation in total per capita energy requirements in Nigerian households.

3.2.3.2 Projecting electricity consumption to 2050

Next, with projections of 100% electrification based on intensity of use, simulations were run for three scenarios: low-energy consumer, high-energy consumer, and optimal energy use. The low-energy and high-energy consumption scenarios were based on household consumption in the locations we surveyed. The optimal-energy use scenario was based on qualitative data on what would be considered a "decent" standard of living in an energy-secure system.

Computing optimal energy use

This standard used the average household size I had computed for the southwestern region, to model the following household demographics as optimal for a base-case energy secure household: the average household size of 5.1 persons, living in a 5 room home (2 bedrooms, living room, kitchen, and indoor bathroom) with electricity requirements to power five light bulbs, a refrigerator, three fans, a television, a radio, a DVD player, an iron, a two-plate electric cooker[7], as well as to power other household productive services at sunset. The energy requirement for each person is a function of household needs as presented in Equation 3.

$$E_i = f(A_i t_i S) \tag{4}$$

[7] Qualitative data indicated that households prefer an electric cooker over the open flame of a gas burner stove.

where E_i refers to the total electricity consumption for the i^{th} person, A_i refers to the appliance rating, t_i is a variable for intensity of use, and S is a function of household size.

The model is of the form:

$$E_i = \frac{\sum_j^{\infty} A_j t_j}{S} \quad (5)$$

This computed value for per capita end-use energy is proposed as the minimal energy poverty line.

Projecting future energy needs

The projections for these three scenarios were used to determine the total name-plate capacity generation required to provide for the Nigerian population's residential electricity needs from 1980 to 2050. With population projections for Nigeria as the independent variable and total household electricity needs as the dependent variable, plots were created to determine electricity supply based on population growth. These plots were compared to current energy generation.

While these estimates are specific to Nigeria's population, they are applicable to most of sub-Saharan Africa which has similar climate, nutrition and dietary products, and value systems. Increase in affluence directly translates to an increase in electricity consumption, more so than would be expected in the traditional ascension of the energy ladder from traditional fuels to modern energy. It would be quite normal for individuals to forgo payment of rent in the purchase of electronic gadgetry and be effectively homeless.

I also compared historic generation of some sub-Saharan West African countries to the proposed energy poverty line.

3.3 Results

3.3.1 Mapping Urban Electricity Consumption

The per capita electricity consumed is represented in Equation 2, where E_i refers to the total electricity consumption for the i^{th} person, A_i refers to the appliance power rating, δ_i is a variable correcting for intensity of use, and φ_i is a function of the geographic location variable. $E_{ik} = \varphi_k \frac{\sum_0^j A_i \delta_i}{(\sum_0^n S_k)/n_k}$ (2)

where φ, S, and j are household demographic variable coefficients.

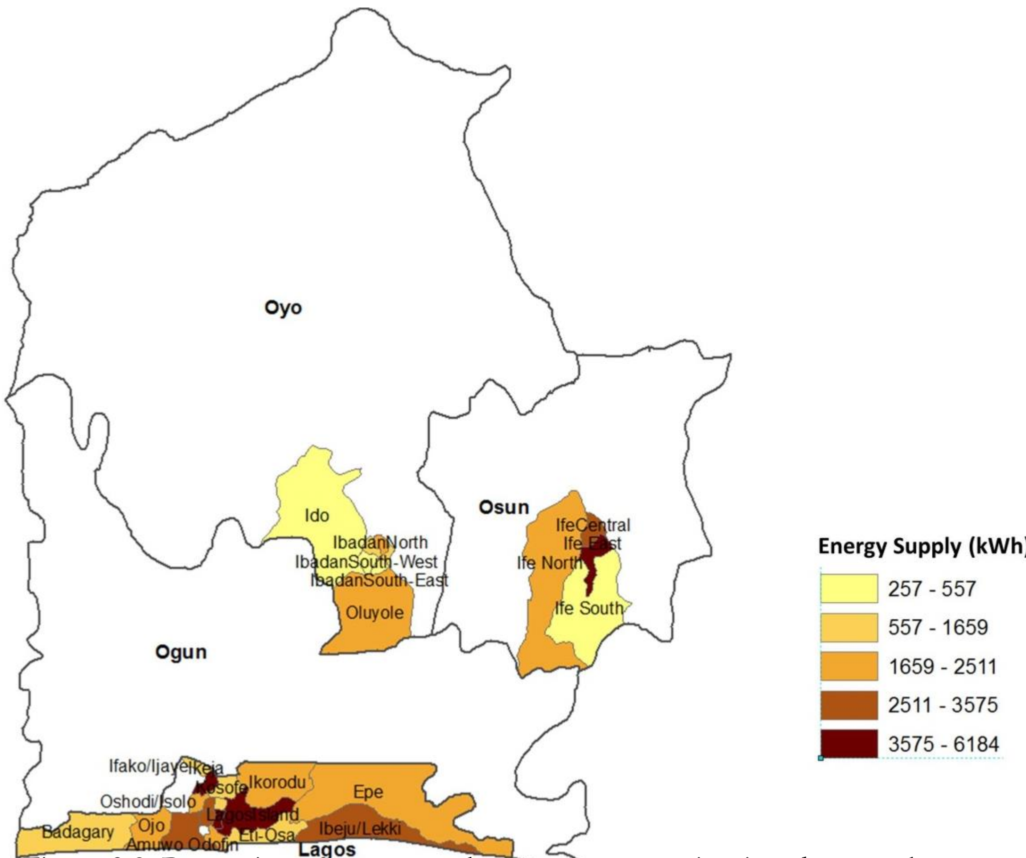

Figure 3.2: Per capita average annual energy consumption in urban southwestern Nigeria.

Source: Author

The energy consumed per capita was mapped for the states of Lagos, Osun, and Oyo (Fig 3.2). Lagos Island was found to use the most energy per capita ($\bar{x} = 3148.2kWh$); the regional average was nearly 1000 kWH lower at 2255.5kWh per capita. The disparity in the consumption per capita for Lagos Island is due to the fact that it has more electricity supply. It is Nigeria's major economic, social, and financial center, and as such it has a more developed and extensive electricity generation, transmission, and distribution network (Abiodun, 1997).

3.3.2 No Correlation between Income, Household Size, and Electricity Access

For the southwestern geopolitical zone, average annual household energy consumption was 2255.5 kWh (Table 3.4). On average, households spent about 15% of household income on electricity expenses, annually. Larger households (with 6 or more persons) consumed, on average, 1482.8kWh annually, or 34% less than households of average size (5.1 persons), and about half (54%) of what smaller households (fewer than 5.1 persons) consumed.

Table 3.4 Descriptive Statistics

Variable	Mean	Std. Dev	95% Conf Intvl	
Average Household Annual Income *(US $/year)*	2757.86	509.09	1748.09	3767.64
Average Household Size	5.1	0.23	4.64	5.57
Average Annual Household Energy Consumed *(kWh/yr)*	2255.5	216	1827	2684
Average Annual Household Energy Expenditure *(US $/yr)*	650	116.02	420.6	880.9
Grid Electricity Supplied *(hrs/day)*	9.08	0.568	7.96	10.21

To investigate this trend, a linear regression was carried out to determine whether annual household income had an impact on the total energy consumed. With average per capita electricity consumption as the dependent variable and household size as the independent variable, household income was found to be statistically relevant ($p = 0.033$). However, income differences only explained 4.3% of the variation in household energy-consumption habits, with a one dollar increase in income resulting in a 0.0246 kW increase in average annual household energy consumed.

Next, I used the Pearson correlation to determine whether there was a statistical relationship between household size and total electrical energy consumption. With $r = -0.38$, there was an inverse relationship between total household energy consumption and household size. The more people in the household, the poorer the household and the fewer the number of appliances owned—thus, the less electricity consumed (see Table 3.5).

However, this relationship was not sufficient to explain the effect of household size on total household energy consumption ($R^2 = 0.052$). Note that the average household income for households in the second and third consumption quartiles was more than double that of households in the first quartile.

Table 3.5. Quartile Electricity Consumption Demographics

Quartile	# Appliances				Annual Household Income ($ US)				Household Size			
	$\bar{x}$	σ	95% C.I.		$\bar{x}$	σ	95% C.I.		$\bar{x}$	σ	95% C.I.	
1- 529.55 kWh	4.4	0.41	3.57	5.26	1013.42	288.2	417.2	1609.7	6.6	0.79	4.97	8.28
2- 1717.78 kWh	6.3	0.17	5.97	6.65	2431.03	504.8	1397.0	3465.0	5.5	0.51	4.41	6.48
3- 3171.39 kWh	7.2	0.15	6.87	7.50	2494.93	1070.0	296.2	4693.6	4.5	0.33	3.85	5.19

The qualitative data on the relationship between electricity costs and income support the results of the regression analysis of the relationship among income, household size, and total household energy consumption. The regression results may reflect the unavailability of formal credit services and the irregularity of income. The high costs and risks associated with lending to the poor and smaller business enterprises inhibit the creation of formal credit services; therefore, microfinance institutions (MFIs) are the primary source of loans.

However, the high interest rates (21% to 42%) charged by MFIs prohibit borrowing funds for the purchase of personal electric and electronic appliances; these items are bought with MFI funds only when they will be used for entrepreneurial purposes (Anyanwu, 2004). Also, the poorer a household is, the less income available for purchasing electronics and gadgetry that contribute to electricity consumption. However, we cannot infer that that larger households, which are often multigenerational, are necessarily poorer.

Table 3.6. Descriptives for dummy variables

Variable	Definition	Freq
gen	Households that own a power generator	76
inv	Households that own an inverter	5
micro	Households that own a microwave oven	36
frig	Households that own a refrigerator	79
iron	Households that own an iron	100
fan	Households that own a fan	93
aircon	Households that own an air conditioner unit	19
radio	Households that own a radio	97
tv	Households that own a television set	101
DVD	Households that own a DVD player	101
e_stove	Households that own an electric cooking range	44

Unpredictability of income stems from two phenomena. First, for households in which the income earners are self-employed, income is seasonal, increasing during festive seasons or according to weather conditions. Secondly, many employers hold employee salaries in high-interest savings or certificate-of-deposit accounts for periods exceeding six months, so as to benefit from the interest accrued over time. This leaves households subsisting on traditional rotating savings and loan schemes (*isusu*) until salaries are paid. Seasonal incomes and salary holding contribute to uncertainty in the availability of household income, but they also create large bursts of disposable income when the salaries are finally paid or high season for the type of work done arrives.

The unavailability of formal credit services means that appliances, gadgetry, and all big-ticket items are purchased with cash. Living expenses such as rent are also paid in cash, and they are paid in advance for the year to come. Basic electronic and electric appliances are typically purchased during the large influxes of cash, and a majority of households in this study owned such big-ticket items as televisions (96%), refrigerators (75%), and generators (72%). The qualitative data indicates that possession of material goods is valued over investment in human capital in the form of nutrition, education, and basic infrastructure.

3.3.3 Discrepancy in Household Electricity Consumption and Electricity Billing

Most households spent less than 25% of their monthly income on electricity (Fig 3.3), including grid-supplied electricity and that from personal generators. Thus, with current tariff structures, households do not spend as much as has been expected on electrical energy. For a typical household of 5.1 persons and a $1,000-2,000 annual household income range, with electricity consumption of 2900kWh/cap-yr, the annual electricity costs are $369.75. This is equivalent to 36.5% of annual income. The discrepancy between the reported 23% of income paid and the actual electricity costs at 36% of household income is due to the fact that electricity bills are often not paid in full. Electricity is supplied as long as some minimum specified amount is paid. Therefore, families are able to afford to pay for electricity (when it is supplied). Nigeria's power company is subsidized by the government, which creates the artificial pricing of electricity. Qualitative data also shows that households receive the same monthly bill for electricity, even if they have not had any power supply for the preceding month or months, as the case may be. As such, electricity bills are an unreliable measure of actual electricity consumed.

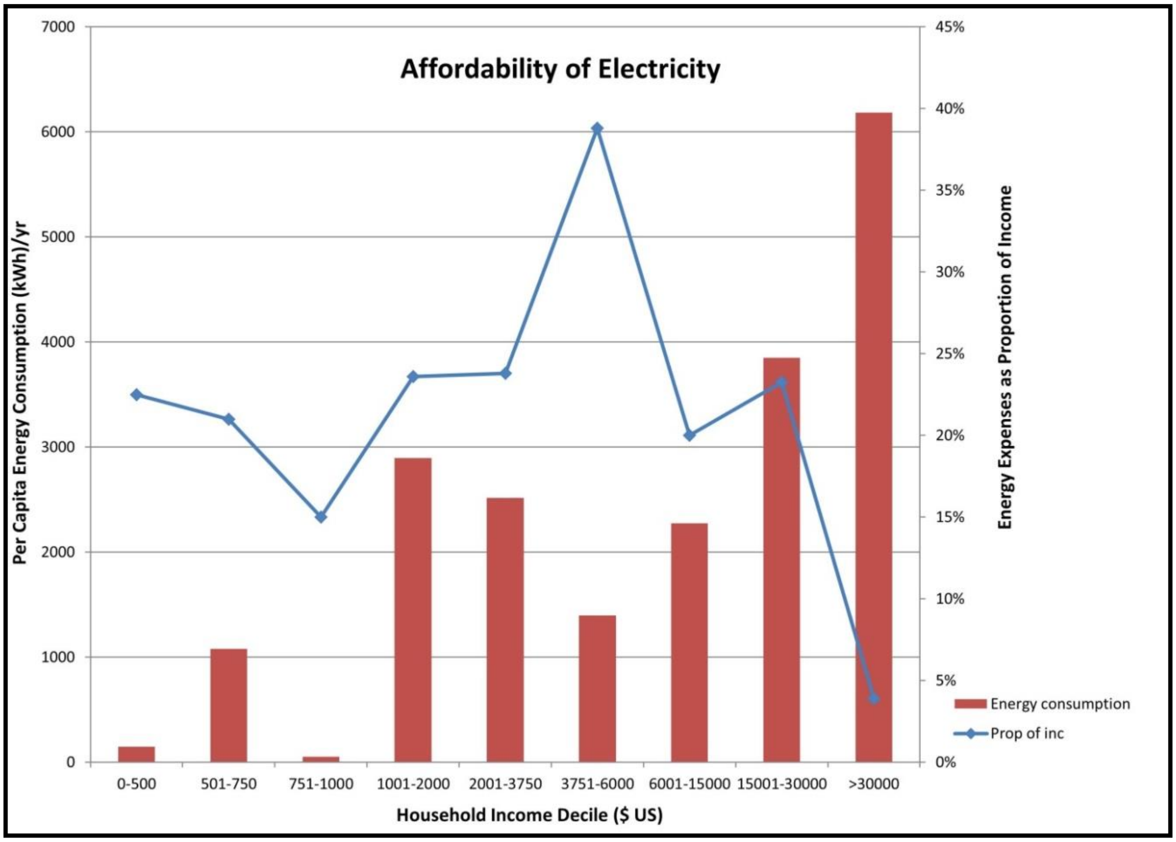

Figure 3.3 Electricity is not affordable for most urban Nigerian households

The current weighted average cost of electricity in Nigeria is 3.2USc/kWh, which is less than half the marginal cost of supply (Ikeme & Ebohon, 2004). The current pricing structure is supposed to be set according to building structure (residential, commercial, industrial, special, and street lighting). In the residential category, consumers are charged for electricity according to four tariff codes (R1-R4), which depend on the types of phase meters (one or three-phase meters) they use or are expected to use. For instance, for residential consumers classified as R1, 2014 monthly residential pricing tariffs for the Ibadan

Distribution Company (DISCO) are fixed service charges of ₦0 ($0 US) and energy charges of ₦4/kWh(2.5 USc/kWh) (NERC, 2013).

In reality, electricity pricing in Nigeria is often based on assumptions about electricity usage and building size rather than on actual consumption data from meters. In the field research, I found that larger single-family homes always had higher electricity bills than smaller, multi-family rental buildings. The electricity bill that is delivered at the end of the month is not based on the actual electricity usage, but rather on the utility company's assumptions about the number and kind of appliances and the maximum number of people that any given type of residential unit is likely to have. The larger a home is, the more people are assumed to reside in it; the greater the number of people, the higher electricity consumption is expected to be. These assumptions about household electricity-use vary widely and are made at the discretion of the local electricity district officials of Nigeria's federal electricity company (Power Holding Corporation of Nigeria (PHCN)). The fact that bills are based on assumed rather than actual use means that the current electricity pricing does not provide an accurate guide for what electricity pricing should in order for independent power producers to operate profitably, nor for what prices are affordable for the average consumer.

Proposing a Minimum Energy Poverty Line

Using the average household size in the southwestern region, I computed a minimal energy poverty line based on the average household size and modeled the following household demographics as optimal for a base-case energy-secure household: 5.1 persons living in a 5-room home (2 bedrooms, living room, kitchen, and indoor bathroom), with electricity requirements to power 5 light bulbs, a refrigerator, 3 fans, a television, a radio, a 2-

plate electric cooker[8], and other household productive services at sunset. The energy requirement for each person is a function of household needs as presented in Equation 3.

$$E_i = f(A_i H_i t_i S) \tag{3}$$

where E_i refers to the total electricity consumption for the i^{th} person, A_i refers to the appliance rating, H_i and t_i are variables correcting for intensity of use, and S is a function of household size.

The model is of the form:

$$E_i = \frac{\sum_j^{\infty} A_j H_j t_j}{S} \tag{4}$$

The computation yielded a minimal energy poverty line of 3068 kWh/cap-yr. This translates to ≈350W/cap-yr of continuously produced power to alleviate energy poverty.

3.3.4 Forecasting Electricity Consumption by Consumer Type

Simulations for high energy use and low energy use were run for three scenarios: low energy consumption, high energy consumption, and optimal energy consumption. The low energy use was based on the lowest-quartile energy consumption of 529.5 kWh and the high energy use was based on the third-quartile energy consumption of 6625.3 kWh. The optimal energy use line is the minimal energy poverty line of 3068 kWh. These three values were converted to power as 60.4W, 756W, and 350W per capita, respectively.

[8] Qualitative data indicated that households prefer an electric cooker over the open flame of a gas burner stove.

The projections for these three scenarios were used to determine the total name-plate capacity generation required to provide for the Nigerian population's residential electricity needs from 1980 to 2050.

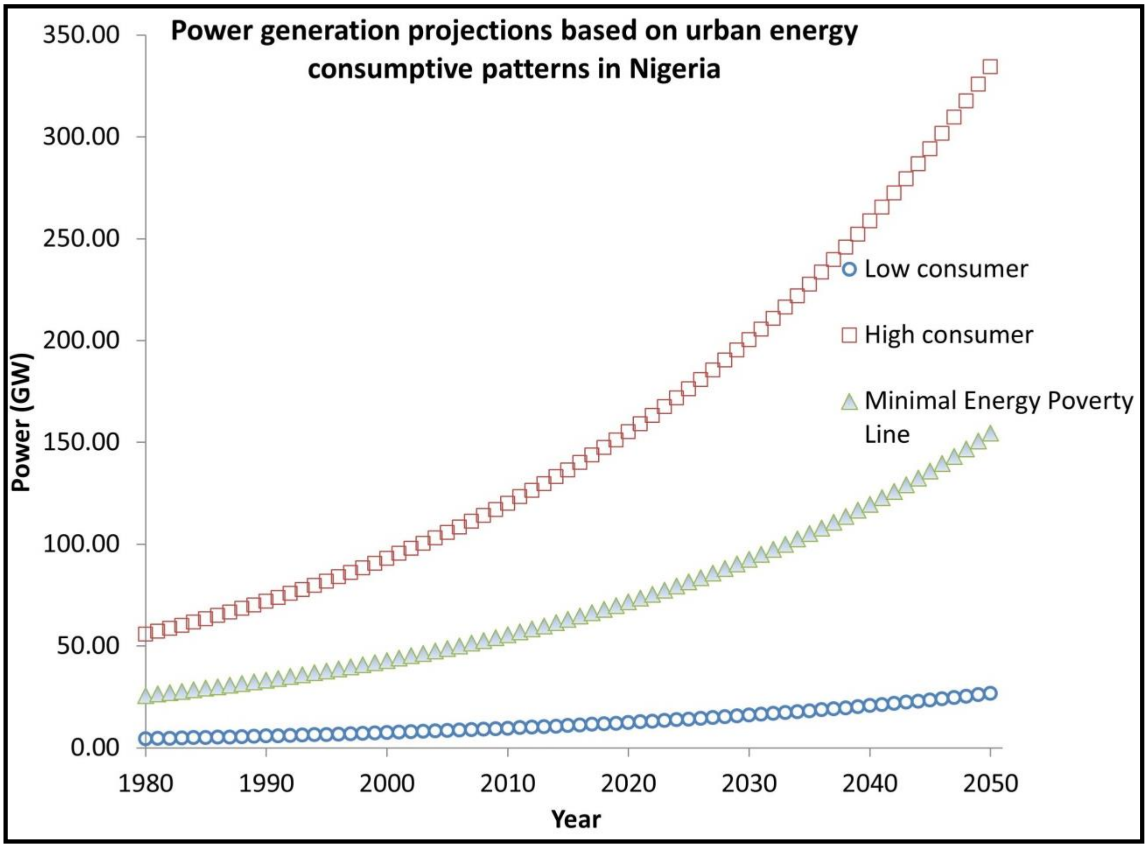

Figure 3.4 Projecting energy needs for urban southwestern Nigeria.

Using the minimum consumption capacity as a benchmark, data shows that even if the entire country were comprised of low consumers, capacity generation in Nigeria from 1980 to present would not have supplied enough power for the entire population (Figure 3.4). Current electricity generation supplies only 31.3% of the energy required for minimal consumption, and only 9.7% of the energy required at the proposed minimum energy poverty line (Figure 3.5). The situation is similar in many sub-Saharan African countries: historical generation capacity falls below the low-consumer level (Figure 6). My simulations indicate that current installed capacity will have to increase eighteen-fold to supply adequate electrical power for Nigeria's current population. Note that the simulation does not take into account efficiency upgrades in types of appliances, or the possibility of a sudden decline in population growth as industrialization occurs. It is a common trend for birth rates to decrease as affluence increases (Myrskylä et al., 2009).

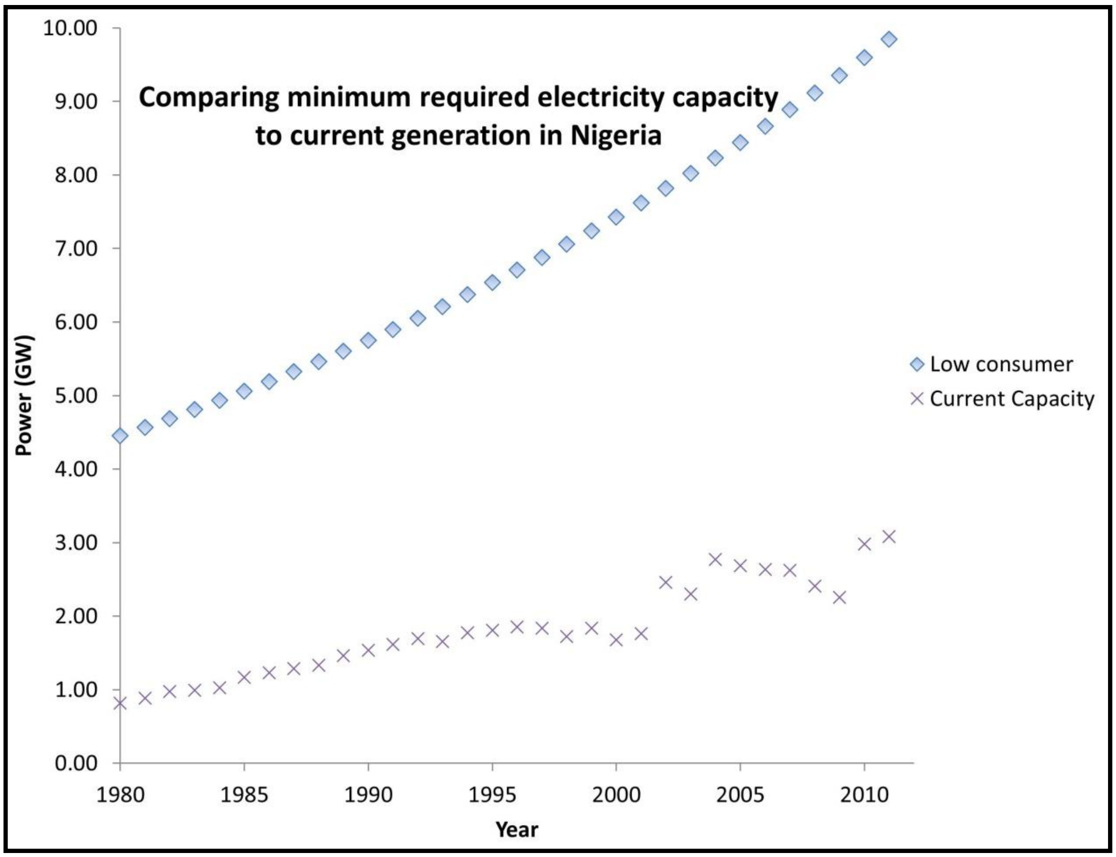

Figure 3.5 Current generation capacity insufficient if entire population were low-consumers

Across the states, most household electricity consumption was between that of low-consumers (less than 529.55 kWh/cap) and the Minimum Energy Poverty Line (MEPL of 3068 kWh/cap) (fig 3.6). This exludes Lagos state which had an even distribution of households that were either at the MEPL range or higher.

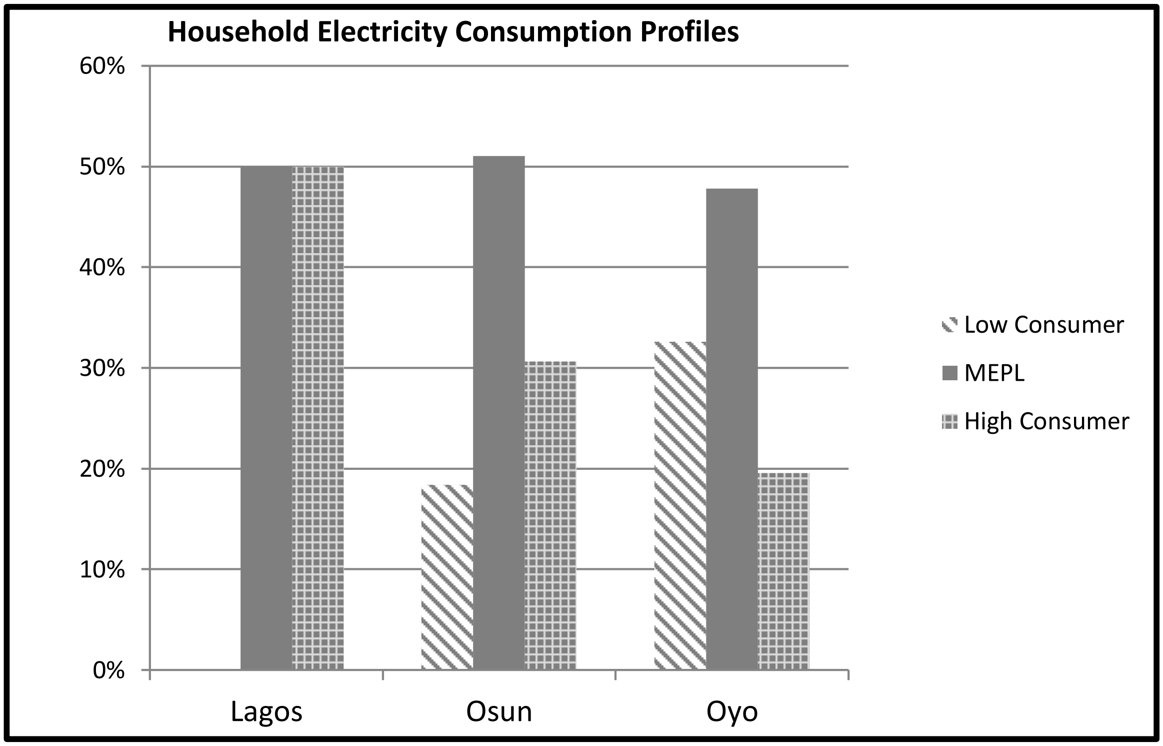

Figure 3.6 Household Electricity Consumption Profiles. MEPL = minimum energy

I also compared the historical electricity generation capacity of select sub-Saharan African countries and they all produced less electricity per capita to supply their populace even if everyone only consumed 529 kWh annually (Fig 3.7).

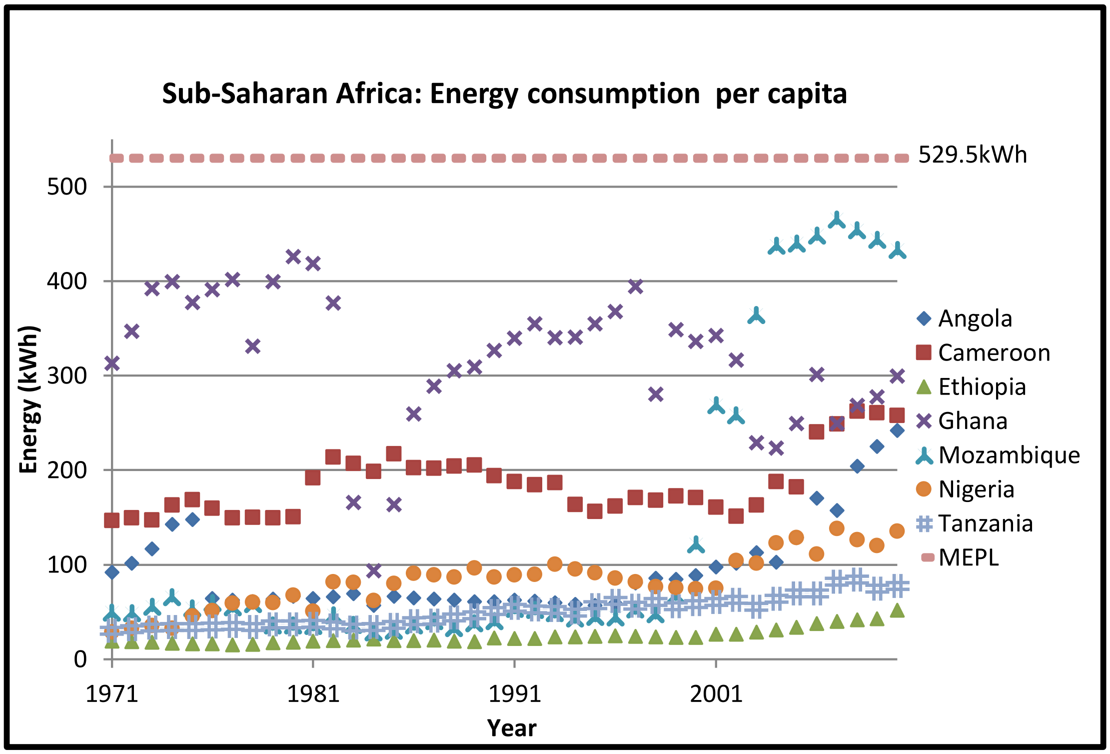

Figure 3.7 Most West African countries name-plate capacity is insufficient for a low-consumer population.

3.4 Discussion

Most present-day energy models are based on the energy systems of industrialized states. However, developing states have different economies and energy choices. They typically lack credit systems and all purchases and financial transactions are made in cash. Low-density fuels (firewood, charcoal, oils) are the predominant fuels for cooking and lighting. While it is impractical to have a universal energy model or energy poverty line, the regions of the world that experience pervasive energy poverty need context-based energy poverty lines.

My study used electricity for lighting, cooking, and other tasks at sunset as a proxy for energy needs. It proposes a minimal energy poverty line of 350W (3068 kWh/cap-yr) per capita to provide for basic needs in urban sub-Saharan Africa. My results indicate that there is no strong connection between income and electricity supply; the country simply produces insufficient power to supply its population. However, I found that smaller households consumed much more electricity per household than larger ones. The explanation for this finding may be that smaller households tend to be nuclear families, which implies that they are wealthy enough to house extended-family members in a separate location. Wealthier households can afford to spend more on consumer electronics, the use of which increases electricity consumption.

If the country were comprised of individuals who all consumed little energy (low-consumers), households would be able to use energy to add value to informal-sector production; the informal sector provides 50 percent of employment in urban areas in sub-Saharan Africa (Meagher & Mohammed-Bello, 1996). For this reason, residential power supply is of utmost importance.

At the minimum energy poverty line of 3068 kWh/cap-yr proposed in this article, electricity costs would approach 25% of total household income. This is considered a high proportion of income to be spent on utilities; Boardman (1991) proposes that utility costs should be less than 10 percent of household income. Full electrification would make the country attractive to external investors, and their investments would, in turn, increase employment and the standard of living. This in turn would be expected to lower the proportion of household income spent on electricity by increasing average household income due to increased employment opportunities. Increases in employment and standard of living would make electricity increasingly affordable.

The model developed here omits air conditioners and climate control electronics in the computation of the minimal poverty line. However, it can easily be adapted to include the increase in affluence that would make their use a norm. However, at the unit cost of electricity and name-plate capacity generation that currently exists, passive cooling and heating strategies such as building design and adaptive behavior would prove more effective.

Nigeria was chosen as a case study because of its unique position as an energy-rich country that nevertheless experiences pervasive energy poverty. Nigeria is an oil-producing state that has large deposits of natural gas; associated gas flares have been burning for over fifty years. Crude-oil deposits are found within impermeable layers of earth strata in combination with natural gas. During mining, the associated gas is vented and flared, as a safety precaution to minimize the occurrence of explosions during installation of extraction equipment. In oil deposits that have significant natural-gas repositories, infrastructure is installed to capture and convey the gas away from the site.

Capturing gas flares presents a unique opportunity to generate electricity from thermal power generation plants. While doing so would seem to fly in the face of the argument against fossil fuel combustion because of climate change concerns, Nigeria's current gas-flaring already accounts for one third of all anthropogenic carbon-dioxide emissions from flaring (Marland et al., 2005). Capturing energy from gas flaring makes much more sense than not doing so.

An energy system riddled with energy poverty produces negative feedbacks, which are evident in Nigeria as well as other sub-Saharan African countries with underdeveloped electricity grid infrastructure. Low electricity tariffs create low returns on investment. The low returns mean that there are limited funds for re-investing in the energy system, specifically for infrastructure for transmission and distribution. They also mean that there are limited resources for preventing infrastructure theft and vandalism. Institutional capacity is limited and characterized by a lack of transparency in policy-making and enforcement. There is little information about exactly how energy is distributed across the grid.

To address these problems, sub-Saharan African countries are considering the decentralization and privatization of electrical power supply. To make this feasible, independent power producers (IPPs) need to know how much electricity they will need to generate to adequately supply power to their customers. IPPs also need information on the cost of producing and distributing electricity so that they can charge appropriate tariffs (subject to approval of the country's energy regulatory commission). To date, such information is nonexistent; without it, there can be no transparency for those who might invest in the electricity sector.

The model presented here can be used to determine how much electricity is needed by a given population. For example, suppose than an IPP is contracted to supply power to the administrative jurisdiction of Ibadan North, which encompasses Agbowo and Bodija, with a total population of 308,119. At the minimum energy poverty line of 350W per capita, the minimum installed capacity required would be 108MW. Since the model compensates for residential load peak time, it is appropriate for computing minimal name-plate capacity for residential and mixed-use neighborhoods, but not for strictly zoned commercial areas. By applying the model, the IPP can gauge the appropriate generation capacity for Ibadan North, the amount of fuel needed to run the power plant, the costs associated with purchasing, installing, and maintaining the plant, and therefore, the tariffs it will be necessary to charge.

3.4 Conclusion and Policy Implications

Most recommendations for addressing energy poverty, and more broadly electricity supply, in sub-Saharan Africa assume that changes to top-down institutional structures will fix problems in the energy system. They do not address how the changes will be accomplished or what the minimum targets for power generation should be. This paper presents a context-specific method of computing per capita energy needs based on consumption data collected in the region, in order to simulate realistic scenarios for an energy-secure future in Nigeria.

There is no clarity as to how affordable electricity will be, as governments in sub-Saharan West Africa consider disaggregating electricity production and distribution. The electricity system must be restructured so that independent power producers can generate enough power to meet actual demand with a price structure that reflects this demand, is profitable for investors, and affordable for consumers.

The Specific Consumption Forecasting method I used in this study is applicable for sub-Saharan Africa because the region has low installed electricity capacity, which in turn means that there is not enough capacity for a correlation between income, household size, and household electricity consumption to exist. However, if installed capacity increases and electricity consumption and expenditures become bounded by household budgetary constraints, a more complex forecasting method such as Artificial Neural Networks would be needed.

Future research will be focused on expanding the spatial scope of this research to increase the sample size and determine if the trends found in this work are strengthened, as well as to compare other geographical regions for homogeneity in results.

3.5.1 Renewable Energy Portfolios in SSA

It is important to note that in the energy poverty literature, especially in sub-Saharan Africa, renewable energy is often associated with distributed generation and off-grid infrastructure for providing electricity in rural areas. This narrow scope impacts how renewables are considered in national electricity generation portfolios in SSA.

Africa has had significant challenges in providing electricity: it houses 13% of the world's population, produces 3% of its electricity with less than 30% of its population having access (Global Data, 2014). In the discourse on providing electricity to escape energy poverty, as well as with concerns of climate change, renewable energy sources need to play a more prominent role in the national electricity generation mix. Solar PV, geothermal, wind, hydro, and biogas have proven to be more easily adaptable for sub-Saharan Africa. Of these five energy sources, hydrothermal power is considered a 'traditional' form of electricity: it is one of the oldest and well-established forms of electricity generation. Most countries in SSA that have large rivers (Angola, Ghana, Ethiopia, and Nigeria, for example) have had hydroelectric power stations producing a significant portion of their electricity. Nigeria, for instance, has 10 hydro power stations operational, with smaller- and medium-sized plants planned in conjunction with multi-national entities.

In addition, there has been success with non-hydro renewable energy technologies including geothermal (Ethiopia and Kenya), solar PV/CSP (Ethiopia, Nigeria, South Africa), wind (Angola, South Africa), and biogas/waste (South Africa, Sudan) with current plans in the works for additional non-hydro power plants. There are significant challenges associated with increasing the proportion of electricity generated by these renewable technologies in SSA. There is an abundance of literature on the capacity of electricity that can be generated by renewable technologies across SSA, however, there is a dire need for the technical workforce needed to keep these relatively new technologies operational. Excluding countries like South Africa, there is limited buy-in for non-traditional renewable technologies (i.e. non-hydro). These include, but are not limited to local manufacturing of replacement parts for these technologies. Issues related to dispatchability and intermittence must be factored in in designing an electricity portfolio mix that is sustainable.

A viable energy system requires a trained and skilled technical workforce, updated and adequately maintained physical infrastructure, and secure distribution and transmission systems. Without these, it would be difficult to meet the energy needs of the population, even if it were comprised entirely of low-energy consumers.

An adequate supply of affordable, reliable electricity is not just the first, but a crucial step out of the cycle of extreme poverty in sub-Saharan Africa. The informal sector contributes half of the economy of the region's countries, and residential electricity supply, which includes energy for added value to production, is essential to empower individual and grassroots initiatives to escape from extreme poverty. Home-based cottage industries, such as food production and storage, for instance, need a reliable power source in order to operate, much less grow. Otherwise these industries cannot develop to the point that they can make a significant enough contribution to the economy to alleviate poverty.

Acknowledgements

I would like to acknowledge the National Security Education Program (NSEP) Boren 2012 Fellowship, as well as the Arizona State University (ASU) Sigma Xi Chapter Grants-in-Aid of Research, for their financial support of this research. I am also grateful to Dr. Kathy Kyle at the Arizona State University, School of Sustainability, and Dr. Kathleen Hancock of the Colorado School of Mines. Special thanks go to Dr. Adenikinju of the Center for Policy, Energy Economics, and Law (CPEEL) at the University of Ibadan, for logistic support.

References

1. Abiodun, J.O., 1997. The challenges of growth and development in metropolitan Lagos, in: Rakodi, C. The urban challenge in Africa: growth and management of Its large cities. United Nations University.

2. Ajayi, O.O., 2010. The potential for wind energy in Nigeria. *Wind Engineering,* 34 (3), 303–312.

3. Ajugwo, A.O., 2013. Negative effects of gas flaring: the Nigerian experience. *J. Env Pollutn and Hum Hlth*, 1(1), 6-8.

4. Akinbami, J.F.K., 1994. Forestry, development and environment - the energy connection: Nigeria case study. *Renewable Energy*, 5(5), 770-773.

5. Akinbami J.-F.K, Ilori M.O., Oyebisi T.O., Akinwumi I.O., and Adeoti O., 2001. Biogas energy use in Nigeria: current status, future prospects and policy implications. *Renewable and Sustainable Energy Reviews, 5*, 97–112

6. Akinlo A.E., 2009. Electricity consumption and economic growth in Nigeria: Evidence from cointegration and co-feature analysis. *Journal of Policy Modeling, 31,* 681–693

7. Alam, M.S., Bala, B.K., Huq, A.M.Z., Matin, M.A., 1991. A model for the quality of life as a function of electrical energy consumption. *Energy 16*(4), 739–745.

8. Anyanwu, C.M., 2004. Microfinance Institutions in Nigeria: Policy, Practice and Potentials. Presentation. G24 Workshop 29th November, 2004.

9. Asaju, K., 2010. Local government autonomy in Nigeria: politics and challenges of the 1999 constitution. *Intl Jnl of Adv Legal Stud and Govnce*, 1(1), 89-113.

10. Barrett, C.B., and Swallow, B.M., 2006. Fractal Poverty Traps. *World Development. 34*(1), 1–15.

11. Bhattacharyya, S.C., and Timilsina, G.R., 2009. Energy demand models for policy formulation: A comparative study of energy demand models. The World Bank Development Research Group, Environment and Energy team.

12. Boardman, B., 1991. Fuel poverty: From cold homes to affordable warmth. London: Belhaven Press.

13. Brew-Hammond, A., 2010. Energy access in Africa: Challenges ahead. *Energy Policy*, *38*, 2291-2301.

14. Bugaje, I.M., 2006. Renewable energy for sustainable development in Africa: a review. *Ren and Sust Energy Rev*, 10(6), 603-612.

15. Buzar, S., 2007. The 'hidden' geographies of energy poverty in post-socialism: Between institutions and households. *Geoforum*, 38(2), 224-240.

16. Central Intelligence Agency, 2013. "Nigeria." Cia.gov Central Intelligence Agency, n.d. Web 14 Dec. 2013.

17. Chaurey, A., Ranganathan, M., Mohanty, P., 2004. Electricity access for geographically disadvantaged rural communities—technology and policy insights. *Energy Policy*. 32(15), 1693-1705.

18. Cohen, B., 2006. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society* 28 (2006) 63–80.

19. Colenbrander, S., Lovett, J., Abbo, M.S., Msigwa, C., Mabiala, B.M., and Opoku, R., 2015. Renewable energy doctoral programs in sub-Saharan Africa: a preliminary assessment of common capacity deficits and emerging capacity building strategies. *Energy Research and Social Science*. 5,

20. Davis, M., 1998. Rural household energy consumption: The effects of access to electricity—evidence from South Africa. *Energy Policy*. 26(3), 207-217.

21. Energy Information Agency, 2011. Total Energy Consumption in Nigeria, 2010.

22. Energy Information Agency, 2013. Country Briefs: Nigeria. Retrieved from http://www.eia.gov/countries/analysisbriefs/Nigeria/nigeria.pdf.

23. Faleyimu, O.I., Akinyemi, O., Agbeja, B.O., 2010. Incentives for forestry development in the southwest Nigeria. *African Jnl of Gen Agric*. 6(2), 67-76.

24. GoI, 2001. Resolutions of the Chief Ministers/Power Ministers Conference on 3rd March, 2001.

25. Goldemberg, J., Johansson, T.B., Reddy, A.K.N., Williams, R.H., 1985. Basic needs and much more with one kilowatt per capita. *Ambio* 14 (4), 190–200.

26. Goldemberg, J., 1990. One kilowatt per capita. *Bulletin of the Atomic Scientists*. 46 (1).

27. Herendeen, R., Ford, C., Hannon, B., 1981. Energy cost of living, 1972–73. *Energy* 6 (12), 1433–1450.

28. Howells, M., Solomon, M., Bennett, K., Kenny, A., 2002. Energy Outlook for South Africa 2002. National IEP, Energy Research Institute, University of Cape Town.

29. Ibitoye, F.I, Adenikinju, A., 2006. Future demand for electricity in Nigeria. *Applied Energy* 84 492–504.

30. Ifowodo, O. "Paying the Police a livable minimum wage." Vanguard, May 15, 2013.

31. Ikeme, J., and Ebohon, O.J. (2004) Nigeria's electric power sector reform: what should form the key objectives? *Energy Policy*. *33*, 1213-1221.

32. Karekezi, K. and Kithyoma, W., 2002. Renewable energy strategies for rural Africa: is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa? *Energy Policy*, *30*1029-1045.

33. Kebede B., Bekele A., Kedir E. (2002). Can the urban poor afford modern energy? The case of Ethiopia. *Energy Policy*, *30*(11–12), 1029-1045.

34. Kebede E., Kagochi J., and Jolly C. M., 2010. Energy consumption and economic development in Sub-Sahara Africa. *Energy Economics,* 32(3), 532-537.

35. Khennas S., 2012. Understanding the political economy and key drivers of energy access in addressing national energy access priorities and policies: African Perspective. *Energy Policy*, 47(1), 21-26.

36. Lloyd, P., Dick, A., Howells, M., Alfstad, T., 2002. A baseline study for Nkweletsheni. Energy Research Institute, University of Cape Town.

37. Marland, G., T.A. Boden, and R. J. Andres, 2005, Global, regional, and national CO_2 emmissions. Trends: A Compendium of Data on Global Change, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

38. Meagher,K., and Mohammed-Bello, Y. United Nations Research Institute for Social Development. The Social Effects of Globalization. Passing the Buck: Structural Adjustment and the Nigerian Urban Informal Sector. Geneva: UN 1996.

39. Mimmi, L.M., 2014. From informal to authorized electricity service in urban slums: Findings from a household level survey in Mumbai. *Energy for Sustainable Development*, 21, 66–80.

40. Mukasa, A.D., Mutambatsere, E., Arvanitis, Y., and Triki, T., 2015. Wind Energy in Sub-Saharan Africa: Financial and political causes for Africa's under-development of wind energy. *Energy Research and Social Science*. 5, .

41. Myrskyla, M., Kohler, H., Billari, F.C., 2009. Advances in development reverse fertility declines. *Nature*, 460, 741-743.

42. Nau, D., 1995. Mixing methodologies: can bimodal research be a viable post-positivist tool?, *The Qualitative Report*, online serial, www.nova.edu/ssss/QR/QR2-3/nau.html, 2(3).

43. Ngala, G.M., Alkali, B., Aji, M.A., 2007. Viability of wind energy as a power generation source in Maiduguri, Borno state, Nigeria. *Renewable Energy*, 32(13), 2242-2246.

44. Nigerian Electricity Regulatory Commission (NERC). 2013. Tariff, charges, and market rules. Retrieved from http://www.nercng.org/index.php/document-library/Tariff-Charges--and--Market-Rules/

45. Nigerian National Petroleum Corporation (NNPC), 2014. Oil Production. Retrieved from http://www.nnpcgroup.com/NNPCBusiness/UpstreamVentures/OilProduction.aspx

46. Oseni, M.O., 2012. Households' access to electricity and energy consumption pattern in Nigeria. *Renewable and Sustainable Energy Reviews, 16*, 990–995

47. Pachauri, S., Spreng, D., 2004. Energy use and energy access in relation to poverty. *Econ and Pol Wkly* 39 (3), 17–23.

48. Pereira, M. G., Freitasa, M. A. V., and Da Silvaa, N. F., 2011. The challenge of energy poverty: Brazilian case study. *Energy Policy*, 39(1), 167–175.

49. Potts, D. 2012. Challenging the Myths of Urban Dynamics in Sub-Saharan Africa: The Evidence from Nigeria. *World Development* Vol. 40, No. 7, pp. 1382–1393

50. Prasad, G., 2002. Personal communication. Energy and Development Research Centre, University of Cape Town.

51. Sadorsky, P. 2013. Do urbanization and industrialization affect energy intensity in developing countries? *Energy Economics,* 37, 52–59.

52. Sambo A. S., Garba B., Zarma I. H. and Gaji M. M. (2009). Electricity Generation and the Present Challenges in the Nigerian Power Sector. *World Energy Council.*

53. Sandelowski, M., 1995. Focus on qualitative methods: sample size in qualitative research. *Research in Nursing and Health*, 18, 179-183.

54. Sokona Y., Mulugetta Y., and Gujba H. (2012). Widening energy access in Africa: Towards energy transition. *Energy Policy,* 47(1), 3-10.

55. Soriwei, F. "NLC faults move to change minimum wage law." Punch, July 1, 2013.

56. Sovacool, B.K., 2012. The political economy of energy poverty: A review of key challenges. *Energy for Sustainable Development* 16(3), 272-282.

57. Sowunmi F. A., Akinyosoye V. O., Okoruwa V.O., Omonona B. T., 2012. The Landscape of Poverty in Nigeria: A Spatial Analysis Using Senatorial Districts- level Data. *Am Jnl of Econ*, 2(5), 61-74.

58. The White House, Office of the Press Secretary. (2014). FACT SHEET: Powering Africa: Increasing Access to Power in Sub-Saharan Africa [Press release]. Retrieved

from http://www.whitehouse.gov/the-press-office/2014/08/05/fact-sheet-powering-africa-increasing-access-power-sub-saharan-africa

59. Toman, M., Lemelkova, B., 2003. Energy and economic development: an assessment of the state of knowledge. *The Energy Journal*, *24* (4)

60. United Nations Department of Economic and Social Affairs Population Division. World urbanization prospects: the 2011revision. New York, NY: UN. 2012

61. UNDP/WB, 2003. Household energy use in developing countries. A multi country study. Energy Sector Management Assistance Program (ESMAP) of the UNDP and World Bank. Washington, DC.

62. Vermaak C,, Kohler M., and Rhodes B., 2009. Developing Energy-based Poverty Indicators for South Africa. *Journal of Interdisciplinary Economics*, 21,163-195.

63. WEC, 1999. The challenge of rural energy poverty in developing countries. In: (Eds.), World Energy Council and Food and Agricultural Organization of the United Nations, London.

64. Yeager, K., 2001. Electricity development for a sustainable world: bridging the digital divide. *World Energy Council 18th Congress*-Buenos Aires.

CHAPTER 4

AN INDICATOR-BASED SUSTAINABLE TRANSITION MANAGEMENT STRATEGY: BENCHMARKS FOR PRIVATIZING NIGERIA'S ELECTRICITY SECTOR

Abstract

In light of privatization efforts in Nigeria's electricity sector, this paper proposes a transition management strategy that focuses on how to create, promote, and manage these transitions sustainably within the context of current user practices, business models, and governance institutions of the Nigerian electricity system. It specifies the relevant benchmarks in electricity governance within the themes of social, economic, environmental and institutional elements for system shift to sustainable production and consumption. It thus contributes to the knowledge-base of decision-support tools for addressing the complex issue of energy poverty due to the interface of its technology-policy-behavior elements.

Executive Summary

Countries across sub-Saharan Africa are currently pursuing privatization and decentralization of their electricity sectors which have traditionally been vertically integrated utilities, responsible for producing, transmitting, distributing, and setting tariff structures in electricity. There is expectation that an economic model for the electricity sector will minimize inefficiencies, however because utilities like the electricity sector function most efficiently as monopolies, it has the potential to be abused by incumbent power generating and distributing companies. Also, there are limited codified policies and strategies with quantifiable benchmarks to measure success of privatization transition efforts.

This study proposes a transition management strategy that focuses on how to create, promote, and manage these transitions sustainably within the context of current user practices, business models, and governance institutions of the Nigerian electricity system. It specifies the relevant measurable benchmarks in electricity governance within the themes of social, economic, environmental and institutional elements.

It is a long-term management strategy that incorporates lessons learned in the transition, as well as stakeholder input. It is expected to be periodically re-evaluated to ensure that transitions are sustainable so that it serves as a useful decision-support tool for energy policy.

4.1 Introduction

Energy is important for the economic, social, and developmental competitiveness of any nation (Alam et al., 1997). While it is not explicitly listed as part of the Millennium Development Goals (MDGs) it is clearly necessary to achieve those goals for the provision of basics like food, clean water, shelter, health and educational services (WEC, 1999; Toman and Lemelkova, 2003).

Similarly, energy is an indicator of social and development progress, the greater the level of energy security of a given country, the higher its Human Development Index ranking (Barett, 2000). Thus the discourse on energy poverty is based on the premise that poverty in a society is unacceptable and extends to dimensions beyond income – malnutrition, dependency, social and geographical isolation, illiteracy, lack of electricity, lack of income, vulnerability to natural disasters, and civil unrest (Pereira et al., 2011).

Energy poverty is the most pressing challenge facing developing countries (Sagar, 2005) and this is especially true for developing countries in sub-Saharan Africa where energy poverty is tied to economic development and environmental sustainability, amongst other social issues (Wolde-Rufael, 2005). In addition, the region currently has, and is projected to have the greatest number of people without access to electricity by 2030 (Shäfer et al., 2011).

The bulk of electricity research in developing nations is focused on decentralized rural electricity access using renewable energy sources (Mohammed et al., 2013; Alfaro & Miller, 2014; Chaurey & Kandpal, 2010). This is because majority of the energy poor -85%- are in the rural areas of developing and emerging economies (Shäfer et al., 2011). Less attention has been paid to decentralization of the vertical utility monopoly as many nations in sub-Saharan Africa attempt to address the dearth of electricity supply by privatizing the national grid. This is especially important because the population density of the energy poor is higher in urban than in rural areas, and rural-to-urban migration trend is expected to increase over the next 30 years (Chidebell-Emordi, 2015(a)).

While technologically mature, best practice examples in main-grid electricity decentralization, such as the Dutch transition that incorporated distributed generation (Verbong & Geels, 2007) or transitions to low-carbon generation such as the case of Ontario, Canada (Rosenbloom & Meadowcroft, 2014) to name a few, might not be easily transferable to regional and cultural contexts in sub-Saharan Africa (SSA).

Some of these contexts include disparity in the skills of operations and maintenance staff from those in the industrialized nations; destruction of implemented technologies because of lack of familiarity with the technology; and sometimes users not having complete information on the capacity and proper use of installed systems. Thus the sustainable transition to a privatized electricity system needs to be managed with these limitations in mind.

The closest analogue for national-grid electricity decentralization in sub-Saharan Africa is the case of South Africa with similar development timelines and technical limitations at inception. However, the power dynamics due to segregation minimize the similarities in the governance institution landscape (Bekker et al., 2008) such that South Africa is not a best practice model for other developing SSA countries. Thus SSA countries look to examples other rapidly developing economies, such as India, to guide decentralization of the national grid at the regional level.

As the most populous country in Africa, and the largest oil exporting nation in SSA, Nigeria is in a unique position of being a resource-rich country with an energy-poor populace (CIA, 2015). Nigeria has enough energy resources that it supplies the neighboring countries of Ghana, Benin, and Togo with natural gas to fuel their thermal electricity plants (Khennas, 2012). Considering that most of the energy-poor reside in SSA, and the recent move to privatization of its national grid, a sustainable transition strategy is important to prevent adverse outcomes of privatization.

This paper uses the Transformatory Sustainability Research (TSR) framework as a holistic way of addressing energy poverty in the form of electricity access. Using transition management theory within the context of the TSR framework, this paper specifies the relevant benchmarks in electricity governance within the themes of social, economic, environmental and institutional elements for system shift to sustainable production and consumption.

The Nigerian electricity sector is currently in a state of flux as it proceeds with the decentralization of its various systems. For this reason, there is limited information on actual changes that have come about due to these dynamics. This discourse will be limited to the history and current state of its performance as a vertically integrated utility as well as suggestions for adapting new knowledge and strategies for monitoring at the *meso*-scale and *macro*-scale for a sustainable transition.

4.2 Literature Review

Socio-technical systems like the energy sector function as a result of the operation of the technical system within the context of rules and institutions as defined by the interpretation of those rules by the relevant actors (Chidebell-Emordi, 2015(b)). Socio-technical transitions, as such, are a set of processes that create an integral shift in socio-technical systems (Markard, 2012). According to Makard (2012), these changes extend not just to the existing technical system, but other domains such as production and trade, as well as planning and policy making. Most importantly, the interpretation of sustainability is subjective and changes over time (Garud et al., 2010).

Sustainability transitions are a coevolution of the economic, cultural, and institutional landscape of a society, causing radical change (Pesch, 2015). However, since socio-technical systems are highly intertwined with user practices and life styles, value chains, institutional structures and political structures, changes are incremental rather than radical (Rip and Kemp, 1998; Dosi, 1982; Frantzeskaki and Loorbach, 2010) which go in the face of contemporary sustainability challenges (Markard et al., 2012). In the electricity sector, these sustainability transitions involve not just a transition from fossil- and nuclear-fueled generation to renewable energy sources (Foxon et al., 2005; Stephens & Jiusto, 2010), but also the appropriate infrastructure to accommodate a decentralized smart grid (Fox-Penner, 2010).

Geels and Schot (2007) propose four ways transitions occur: *transformation* precipitated by external pressure; *reconfiguration* due to maturity of niche innovation technology in solving internal problems in the system; *technological substitution* of the stabilized mature niche innovations; and *re-alingment and de-alignment* stemming from major destabilization of the existing regime leading to systemic collapse of the technical system.

In the field of electricity generation there is a wealth of literature pertaining to these different transition typologies: high energy efficiency in the Dutch electricity system, a form of reconfiguration transition ((Hadjilambrinos, 2000); transformation transitions due to the external pressure of climate change and the Kyoto Protocol leading to an increase in renewable energy percentages in the electricity portfolio of many western nations (Haas et al., 2011); electric trams replacing horse-drawn trams in Europe and the United States, an illustration of a technological substitution transition due to maturity of technology (Geels

&Schot, 2007). The substitution of electric trams for their horse-drawn counterparts is also a form of re-alingment and de-alignment stemming from major destabilization of the transportation *status-quo*.

According to Geels & Schot (2007), the types of landscape developments that influence these socio-technical transitions include emergence of new markets, population growth, and economic growth amongst others. Change evolves slowly and the responses of the actors to these external pressures with internal resources determine which of the aforementioned transition pathways occur. If the landscape stays intact, this becomes a transformation transition type; if the changes in the system create architectural changes, this is a reconfiguration transition; if substitution niche technology is sufficiently matured to replace the current system this becomes a technological substitution transition; if substitution niche technology is not mature, there will be multiple innovations that develop, co-exist, and die until such a time as one option becomes dominant, creating a re-alingment and de-alignment transition. In every one of these instances agency is important in triggering the transition pathway.

Budde et al. (2012) argue that actors act based on expectations even when operating under similar circumstances of resources and institutional context. These expectations at the landscape level can range from climate change to globalization and inform the dynamics at the regime and niche levels.

Actors in the electricity socio-technical system include policymakers and public authorities, as well as public and industry actors. Policymakers and public authorities traditionally finance the electricity system and the initial phase of innovation (Berkhout, 2006). In developing nations, especially in sub-Saharan Africa, the shortage of electricity supply frames the expectations of the relevant actors at the landscape level with emphasis on globalization. Sometimes, sustainability transitions are defined by the ontological context of the actors and can unintentionally create or sustain systemic problems (Schuitmaker, 2012). For this reason, sustainability transitions are ongoing processes as opposed to pre-defined regime shifts (Markard, 2012). The temporal nature of sustainability transitions requires a reflexive and iterative methodology for operability. Transition management creates this kind of oversight by providing a management strategy for public decision-makers and private actors based on a philosophy that attempts to mitigate uncertainty and complexity (Rotmans, 2001).

Rotmans (2001) describes transition management as having the following characteristics: it entails long-term (25 years or more) considerations in shaping short-term policy, it is multi-domain with multi-level interactions involving multiple actors, and focuses on continuous learning from the ongoing outcomes of the transitions. It also considers a large number of options and allows for system innovation alongside system improvement.
Transition management is initiated with consensus on a vision which needs to be multi-dimensional and not just quantitative (Rotmans et al., 2001). It involves long-term thinking as a framework for shaping policy in the short- and medium-term, encompasses multiple domains, actors, and scale, and is a reflexive and iterative process.

Transitions, which typically span a generation (25 years), experience periods of both slow and fast development. According to Rotmans et al. (2001), there are four transition phases: (i) a pre-development phase in which there is no visible change in the status quo; (ii) a take-off phase where innovation processes and technologies begin to destabilize the system and the process of change initiates; (iii) an acceleration phase due to the accumulation of innovations in socio-cultural, economic, and institutional domain which reach with each other and are facilitated by collective learning, diffusion, and embedding; and finally, (iv) a stabilization phase in which the speed of social change decreases and a new dynamic equilibrium is reached.

The speed with which transitions occur and the dynamics and pathways of transformation depend on the adaptability of actors and institutions, as well as their capability to anticipate, adopt, and integrate new technology, knowledge, and practices (Dolata, 2009). Sustainability science by definition takes a holistic approach that factors in the dynamic interactions between the socio-ecological parts of the system. These interactions are based on the social, economic, and environmental elements of sustainability which are all linked via governance institutions (Sharma & Balachandra, 2015). Ignoring one or more elements of this dynamic system will lead to perverse outcomes in a best-case scenario, and eventual system collapse in a worst-case scenario.

Studies in sustainable transitions in electricity and energy seek to understand how the introduction and development of renewable technologies can be promoted (Normann, 2015; van der Schoor & Scholtens, 2015; Sgouridis et al., 2013). These range from biofuels to solar PV, and wind. The onus of these initiatives is climate change thereby focusing only on environmental sustainability. Thus, while the ultimate aim for a sustainable energy system is one which energy is provided with minimum impact on the environment, producing a vital economy within the context of social equity, there is a chasm between the current state of energy systems in developing nations and this ultimate vision. Often these initiatives are well-meaning: in 2013 the U.S.-led initiative, Power Africa, was launched by President Barak Obama to increase power generation in Africa by adding 10,000 MW of cleaner, more efficient generation capacity in more than 19 African countries (The White House, 2013).

The Power Africa project addresses the installation and upfront operation of these renewable energy power plants but fail to delve into causes of energy governance failure.

Studies indicate that for both these renewable electricity power plants and the traditional power plants (hydro, thermal), energy management culture and the lack of human capital are the cause of system failure. There is no knowledge of what the baseload should be as there is no research conducted on electricity consumption. This in turn implies that name-plate capacity for power plants is a guesstimate. This affects the distribution network leading to brown-outs and failure within the transmission network. These factors are exacerbated by an engineering culture in which cheaper non-compatible components are interfaced within the installations jeopardizing the structural and mechanical integrity of the system (Adeyemo, 2013). There is also a lack of educated and trained technical personnel equipped to run and maintain these installations. In the case of these new renewable energy systems, these symptoms have already begun to manifest as in the case of the solar electrification project in Onisowo, Lagos state, Nigeria and similar projects in the other states of Zamfara, Bauchi, Benue, Bayelsa and Rivers that all experience problems with efficiency and maintenance (Oirere, 2014). This is further compounded by the fact that non-hydro renewables are for the most part completely novel technologies, and all resources need to be imported: from solar panels to technicians. It does not bode well for the sustainability of these projects.

Sustainability science is place-based, incorporating knowledge of cross-scale challenges and scaling up from the local problem to the global issues (Kates et al., 2001; Clark and Dickson, 2003; Komiyama and Takeuchi, 2006). For this reason, sustainable energy transitions must also be place-based. This paper proposes a multi-level indicator-based transition management strategy in the transition from an energy-poor system to an energy-secure one and eventually a sustainable system.

Transition objectives are formed visions of the relevant stakeholders and have practical applications outside the realm of science. This paper focuses on how to create, promote, and manage these transitions sustainably within the context of current user practices, business models, and governance institutions of the Nigerian electricity system and thus contribute to the knowledge-base of decision-support tools for addressing the complex issue of energy poverty due to the interface of its technology-policy-behavior elements.

4.3 Research Design and Methodology

Sustainability problems encompass different magnitudes of scales (temporal, scalar, and functional), multiple dynamics, multiple actors, and multiple system faults (Reitan, 2005). This paper limits the scope to Nigeria's national electricity system, the actors within that system, and the inadequate supply of electrical power within the system.

The electricity system is Nigeria is on the cusp of a re-alingment and de-alingment form of transition due to the collapse of the system. It exhibits the classic symptoms of this form of transition as outlined by Verbong and Geels (2010): there is insufficient production of electricity, massive infrastructure collapse, loss of faith by actors, as well as a sustained period of uncertainty filled in by experimentation with self-generation[9] and renewables as distributed generation (Chidebell-Emordi, 2015(b)). In order to understand the current state, propose sustainable visions, and manage the transitions from the current state to the desired future state, this paper uses **Sustainability Transition Management** within the **Transformational Sustainability Research** to create indicator-based transition management strategies to ensure quantifiable sustainable transitions.

Qualitative data used for visioning was collected via participatory research in order to gather an understanding of lived experiences as a group or at the individual level (Silverman, 2006). Qualitative data helps to understand the subtle nuances of the state of energy poverty

[9] Self generation refers to individual household utilizing portable gasoline-powered generators for electricity production.

within its context and reduce the distrust of the people being studied (Macaulay et al., 1999, pg. 774). It also helped to understand social actor's perspectives, as well as validate data obtained from other sources (Londof, 1995).

Both theoretical conceptual frameworks and data collection methodology are subsequently discussed.

4.3.1 Transformational Sustainability Research (TSR) framework

Transformational Sustainability Research (TSR) is a solutions-oriented framework to develop and test sustainable transition strategies through co-production of knowledge and solutions among scientists, policy-makers, and stakeholders (Wiek & Childers, 2010). TSR has three components – (i) a problem analysis that generates knowledge of the current state, past developments and contemporary dynamics to determine causation; (ii) crafting of sustainable visions via scenario-construction for possible future states; and (iii) intervention planning that develops transition pathways as well as intervention strategies from possible critical tipping points and irreversible trajectories (points-of-no-return), to the sustainable vision (Fig 4.1).

4.3.1.1 Problem analysis

This element of the framework seeks to answer the following questions: what does energy poverty in Nigeria look like today? Why is there energy poverty in Nigeria? Who are the actors at the different scales within the electricity system? How do they act? How do these actions affect the system?

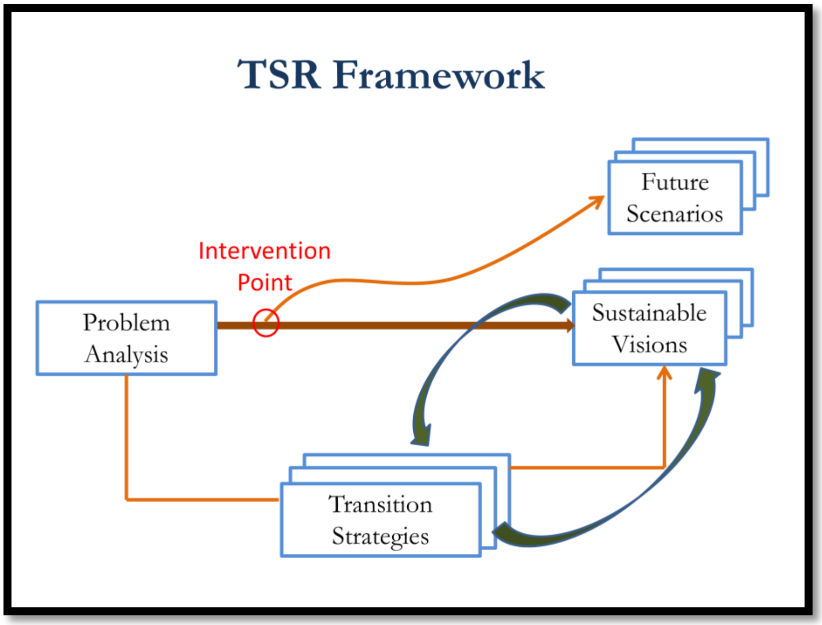

Figure. 4.1 Transformatory Sustainability Research (TSR) framework, adapted from Wiek & Childers, 2010.

This information would help gain an understanding of the current state and craft sustainable visions through participation of the relevant stakeholders, from policy makers to the energy poor, while taking into account the complexity of different perspectives, values, preferences, and types of evidence.

Defining the system boundaries

The first step in answering these questions in the case study area is to define the system. This is done by defining the boundaries, its components, and the interactions of those components as relates to the problem (Remington-Doucette, 2013).

The boundaries of this problem encompass spatial, temporal, and functional dimensions. The spatial boundary under consideration is geographic, limited by the physical infrastructure of the Nigerian national electricity grid. Document analysis of relevant reports, as well as historical archival documents from the National Electric System Operator (NESO) were used to create the organizational map of the vertically integrated system, as well as the new privatized system.

The temporal scale covers the time period in which the electricity system was a vertically integrated public utility, from 1950 to 2014 (Chidebell-Emordi, 2015(a)). Data from literature reviews from an academic journal database as well as publicly available historical archival documents were used.

Current state of energy poverty

Nigeria's electricity system will be specified within its spatial, temporal, and functional scale. Qualitative data from participatory research as well as quantitative information from literature reviews of urban electricity consumption in the region will be used to supply this information.

Actors and their interactions

Actors within the electricity socio-technical system are often broadly categorized into producers and suppliers (Parag & Janda, 2014). In this paper, the producers extend to the generation, transmission, distribution, and regulatory entities, while the consumers refer to the households, cottage industries and larger manufacturing and production facilities. Data from the Nigerian Electricity Regulatory Commission (NERC) will be used to illustrate the connections as well as feedback loops amongst the actors in this electricity system.

4.3.1.2 Sustainable Visions

Sustainability science relies heavily on stakeholder engagement for bridging gaps between research and practice, addressing social and environmental justice for capability building (Cargo, 2008). Through participation of the relevant stakeholders, from policy makers, to the energy poor, this vision takes into account the complexity of different perspectives, values, preferences, and types of evidence (Wiek & Childers, 2010). For instance, in sub-Saharan West Africa, the past is more important than the present, and the present than the future. This value system must be acknowledged, and the limitations it presents in crafting future scenarios would require the sustainability scientist to challenge cultural assumptions, decoupling vision crafters from previous mental models.

Visioning exercises were conducted to answer the questions pertaining to a desirable, sustainable vision for energy security as well as the *relevant short, medium, and long term benchmarks*. It was up to the researcher to determine if the proposed visions met sustainability visions quality criteria based on Gibson's core generic criteria for sustainability (Wiek & Iwaniec, 2013; Gibson, 2006). Each visioning session lasted for an hour.

4.3.1.3 Transition Strategies

Transition strategies to the desired sustainable vision incorporate setting goal-oriented benchmarks, learning from unanticipated problems, continuous monitoring, evaluation for integrating new knowledge, and social adaptation (Grunwald, 2007). A "backcasting" approach is normally used to determine the steps from the desired vision to the transition strategy. However, the absolute paucity of electricity supply inhibits this process. Moreover, this study is focused on transitions with immediate adaptability. These transitions will be informed by the qualitative and quantitative visioning benchmarks to tie practice-oriented steps to governance approaches by proposing criteria with which to measure performance sustainability of the proposed transitions.

4.3.2 Sustainable Transition Management

There are four requirements of transition management: knowledge generation, integration, adaptation and transdisciplinarity (Wiek et al., 2006).

The types of knowledge generated include information on the system current state and causation, guiding knowledge on visions, norms, and preferences, and transformatory knowledge pertaining to strategies, political and economic constraints as well as conflicts (Dortmans & Eiffe, 2004; Wilkinson & Cary, 2002).

Once the transition phase has initiated, spurred on by the de-alignment and re-alignment in the system, knowledge is integrated into the planning phase that includes goal-formation, analyses, assessments, and strategy building. Next, system changes shape the transition by introducing new knowledge that is adapted and the transition process transforms after its first iteration from a "learning by planning" type to a synthesis of "learning by planning" and "learning by doing" (Fig 4.2). Finally for the transition to be successful it must include various stakeholders, from scientists and experts to individual and governance stakeholders at the different levels (Wiek et al., 2006).

A reflexive and iterative method is proposed to evaluate the sustainability of the transition process, checking to see if the short-, medium-, and long-term electricity consumption goals have been met, and creating intervention point strategies to deal with unrealized benchmarks while adapting new knowledge.

Within the social, economic, environmental and institutional elements of a sustainable transition qualitative and quantitative benchmarks give measurable progress on which to assess the success of the transition.

Drawing from previous work done by Sharma & Balachandra (2015), Shortall et al. (2015), and Vithayasrichareon (2012), a multi-level indicator-based framework is proposed to evaluate progress in the transition by specifying indicators in the social, economic, environmental, and institutional dimensions of the electricity system.

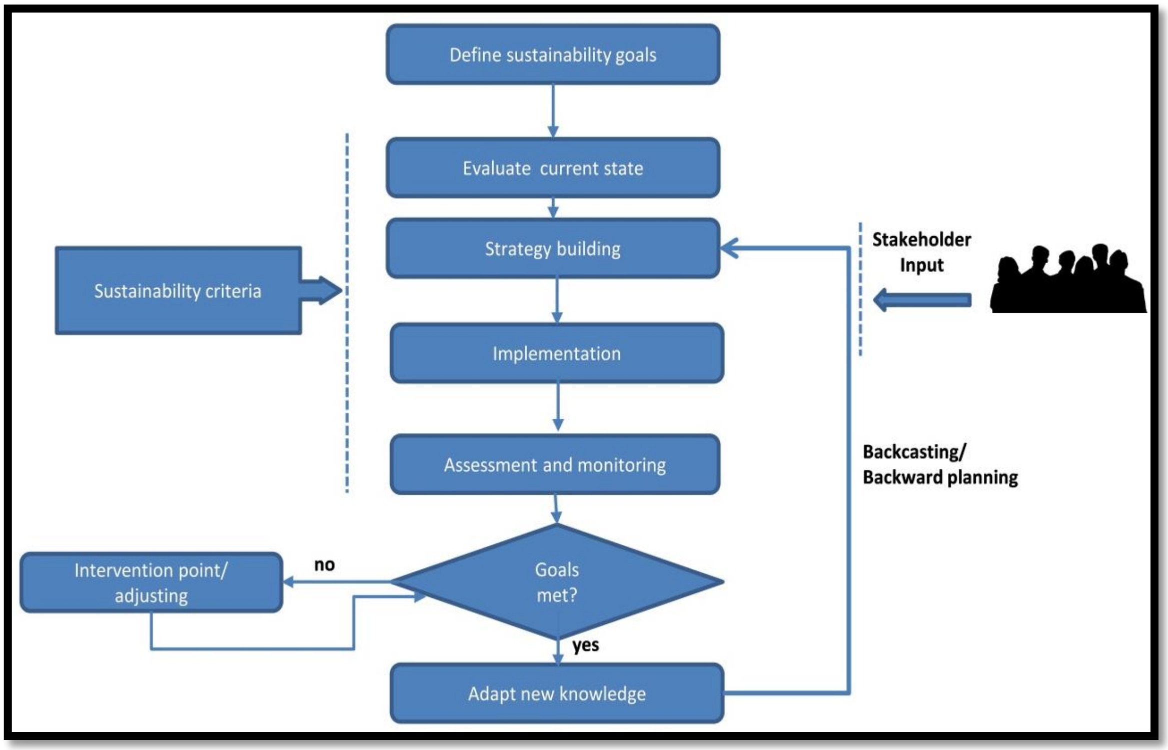

Fig 4.2 Assessing progress in sustainability transitions using indicators

4.3.3 Data Collection

This study was approved by the Institutional Review Board at Arizona State University. Qualitative data was compiled from focus groups, group interviews, and expert interviews which were conducted at the Federal University of Ibadan in Oyo state, Nigeria. Eligibility criteria included residency in Oyo state and fluency in the English language. Participant selection for both focus groups and group interviews were conducted with the purpose of ensuring that the research question would be addressed, while including some participant diversity, thus allowing for a range of participant points of view (Saldana, 2009).

Recruitment for focus groups, group interviews, and expert interviews was accomplished via chain sampling. The researcher initiated prospective stakeholders to participate and make recommendations for additional candidate that fit the research criteria (Biernacki & Waldorf, 1981).

All candidates consented to expert interviews, group interviews, and focus group sessions after receiving in-person description of the study and their prospective roles. Due to subtle cultural nuances that influence power dynamics, three separate sets of group interviews as well as focus groups were conducted: with adult members of the public across gender, income, education levels, and ethnolinguistic affiliations; graduate students at the federal university; and faculty at the federal university.

The focus groups sessions were semi-structured, allowing for guided but unconstrained conversations. Focus groups were conducted to ascertain the local vision of energy security, specific to electricity supply. The primary purpose was to stimulate discussion in line with the described research approach. Focus group sessions lasted for approximately 45 minutes with 15 participants per group, achieving saturation when no new themes emerged.

Similarly, group interviews were semi-structured and pertained to lived experiences of lack of electricity supply. Saturation occurred when no new analytical insights were gleaned; group interview size was 15 participants and sessions ran for approximately one hour.

In these group settings, the researcher took measures to minimize gender bias as much as possible, as well as “false” consensus from dominating participants (Litosseliti 2003 pp 22).

These were complemented by qualitative interviews with experts in Nigeria's energy sector. For the purpose of this study, experts refer to Nigerian nationals who are professionals in Nigeria's oil and gas sector. This study limits the scope to those who have represented the country at national and international level deliberations such as the NNPC, the World Bank, the United Nations, and the Department for International Development (DFID). For expert interviews, questions were more in-depth, eliciting information on the actor networks and the physical electricity grid. Interviews lasted for roughly 40 minutes each.

Due to the unique nature and scope of the topic, saturation occurred quickly and saturation size was achieved at 15 participants for group interviews and 5 participants for expert interviews (Bertaux, 1981; Morse 2000 pp 4) (See Appendix B for coding methodology).

Before integrating qualitative and quantitative data, each dataset was analyzed and interpreted separately according to the process described by Rosenberg et al. (2013). Next, general themes were identified and coded based on relationship to quantitative data collected. Finally the information extracted was used to inform gaps in literature review and quantitative data collected.

4.4 Results

The current state of energy poverty is briefly described in terms of the country's history and enabling institutions, coded themes of lived experiences, as well as actor networks in the electricity system to give context to the state of electricity supply. The results of visioning exercises in determining local perspectives of sufficient electricity supply are contrasted with literature on electricity supply in relation to levels of development. Finally within the context of current user practices, business models, and governance institutions of the Nigerian electricity system, indicators that are appropriate for a sustainable transition are specified as benchmarks for practice-oriented approaches.

4.4.1 Past and current state analysis

Prior work that delves into causation and contemporary dynamics provided a rich analysis of the current state of energy poverty in Nigeria. It found that the type of colonial governance, ethnic heterogeneity, and public service consumptionism are the primary factors that create the mental models that lead to weak governance both in energy, as well as other sectors in Nigeria (Chidebell-Emordi, 2015(b)). According to Chidebell-Emordi (2015(b)), colonies were expected to be self-sufficient and employed strategies to make resource extraction expedient: Africa was arbitrarily divided into nation-states, splitting indigenous nations between two, and sometimes three colonial entities; indirect rule was employed in non-settler colonies; and multiple tribal nation groups were coalesced into nation states lacking a unified national identity. These strategies created illegitimate leadership, mental models of elitism and complete dependence on the state for all public goods (Public service consumptionism), as well as models of resource extractive governance, leading to rent-seeking and weak governance institutions. In the electricity sector, this weak institutional capacity is illustrated by the absence of quantifiable or progressive benchmarks in electricity production, transmission, and regulation in the country's energy policy. It produces challenges in the form of compromised infrastructure, insufficient supply, and inadequate access to electricity.

4.4.1.1 The electricity sector

Nigeria's electricity sector contributes to only 4% of national GDP (Economist, 2010). This is important considering that the cottage industry in Nigeria comprises 80% of all registered businesses (Ogechukwu, 2011), and 95% of wood fuel consumption in Nigeria is used for cooking and food processing (Oyedepo, 2012). Studies in urban southwestern Nigeria show that only 3% of households have access to energy dense cooking fuels in the form of electricity and gas; in addition, households have an average of 8 hours of electricity supply per day (Chidebell-Emordi, 2015(b)).

In response to the rolling blackouts and brownouts, self-generation has turned out to be the dominant option in response to the massive system collapse of the electricity sector, equivalent to 20% of installed capacity (Foster and Steinbuks, 2009). Studies show that self-generation with portable generators accounts for 72% of electricity supply for residents in urban southwestern Nigeria (Chidebell-Emordi, 2015(a)). Other estimates have put private generation for the commercial sector at 90% ownership with trans-national corporations like Coca-Cola and Procter & Gamble relying on self-generation for a 100% of their power supply (Connors, 2009).

Self-generation is not a sustainable option for electricity supply: the cost of self-generation is three times as high as the cost of grid electricity. It increases capital and operating costs, reduces competitiveness of local products, and hinders achieving economies of scale (Steinbuks & Foster, 2010). The insufficiency of the national electricity company to meet the electricity needs of an increasing population is apparent in widespread blackouts and inordinate electricity pricing. The latter created negative feedback loops that led to brownouts and load shedding over the past three decades (Chidebell-Emordi, 2015b).

While literature holds that the energy poor spend a significant proportion of their income on energy (Buzar, 2007; Sovacool, 2012), electricity prices are subsidized in Nigeria, and consumers need pay only a portion of their bill to continue receiving service. However, households are billed a fixed amount every month, based on the classification of the building type, irrespective of how much electricity they consume (Chidebell-Emordi, 2015(a)). Even as the Nigerian electricity sector is transitioning to a privatized system with metered consumption to increase transparency, there is resistance to this change with old actors within the new organizations. Some reports have the new power distribution companies sending out these "guesstimate" bills rather than reading the prepaid electricity meters, even when there have been blackouts for weeks (Fabowale, 2015).

The impact of energy poverty is multidimensional: it impacts a household's ability to earn an income, have assets, or savings so as to withstand economic and external shocks, affecting their financial capabilities; it limits access to adequate healthcare, education, nutrition, and other sanitation services, affecting human capabilities; low financial and human capital infer that energy-poor households are unable to participate as valued members of society, extending to their political capabilities which determines how much influence over, and participation in public policies that affect them. These dimensions of energy poverty are all interrelated and impact each other (See Table 4.1).

Table 4.1 Coded themes of energy poverty

Theme	Sub-theme	Representative Quotes
Financial Capital	Fewer income-generating activities	"I'm only in school because I cannot afford to run my business; the price of fuel (to run the generator) is too high." - Male participant "I used to sell frozen chicken, frozen turkey, and those things, but the price of fuel is too high because there is no light. I was not making profit again so I closed shop." – Female participant
	Low productivity	"Because there is no light (electricity), we don't make much profit, we spend too much on petrol." – Female participant " If there was light we can have bigger machines to grind stuff[10]; we can make more money that way." – Female participant "Sometimes they will take light while I am barbing a customer's hair, now I will have to turn on the generator, but I cannot charge the customer a different price because I have already started." – Male participant
Human Capital	Education resources	"If there is light, internet service will be more reliable." – Male participant
	Safety	"I will like to use electricity to cook instead of gas; it is safer for the little children." – Female participant

[10] Commercial mill used for grains, and vegetable purees.

4.4.1.2 The Vertically integrated System of Nigeria's Electricity System

Actors within the electricity socio-technical system are often broadly categorized into producers and suppliers (Parag & Janda, 2014). Post-independence up until 2002, the Nigerian Electric Power Authority (NEPA) was the sole producer of electricity in charge of the generating plants, the transmission and distribution network as well as the setting of tariffs (Chidebell-Emordi, 2015(b)). With the inability of NEPA to meet the needs of the growing population, in 2002 the Power Holding Company of Nigeria (PHCN) was created in preparation for the unbundling of the electricity sector. During this time the only actor at the different scales of the electricity sector was the state (Fig 4.3).

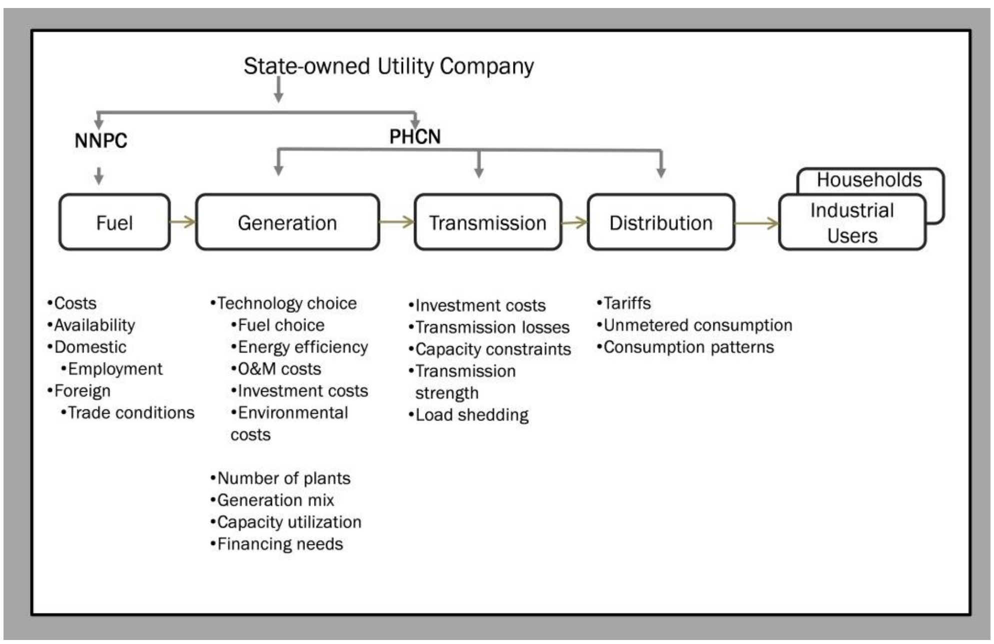

Figure 4.3 Pre-transition electricity system (1960-2014)

In its current transitory state, Nigeria's electricity sector is managed by public-private partnerships (PPPs) between the Ministry of Energy, through the Nigerian Electricity Regulatory Commission (NERC), and private companies (Fig 4.4).

Tariff-setting was created by NERC via the Multi-Year Tariff Order (MYTO) and will remain in place for the next fifteen years, or until such time as the electricity marketplace matures as evidenced by healthy competition (NERC, 2015).

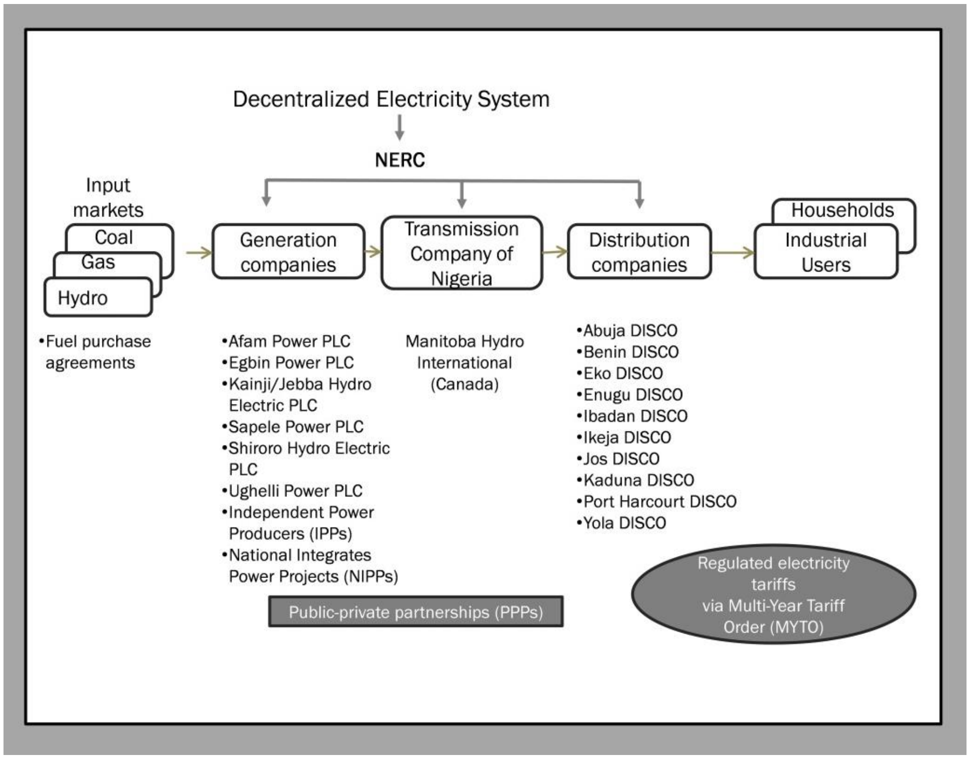

Figure 4.4 Transitory electricity system (2014 -)

4.4.2 Sustainable Vision

A sustainable vision for Nigeria ideally describes a future desirable state which entails a cohesive vision using multiple narratives provided by the stake holders. Visioning exercises were conducted to ground quantitative benchmarks in the realities of the stakeholders, subject to sustainability criteria. The results of visioning exercises are subsequently discussed.

4.4.2.1 Visioning in the worst case scenario

Visioning exercises in participatory research are used to elicit spontaneous feelings and concerns of relevant stakeholders based on their experiences, views, and concerns. Participants were asked to describe their vision of what constitutes an "ideal" and "expected" state of energy security with regards to electricity supply.

At this juncture it is important to describe the impact of asking the open-ended question - *what does an energy-secure Nigeria look like? How much electricity access would have an impact on your livelihood?* This question was asked with the different stakeholder groups. For all groups: lay persons, undergraduate students, graduate students, and energy experts, the responses were the same.

First, deafening silence for two to three minutes. The contrast of this reaction to the animated responses to the previous questions as to the impact of inadequate electricity supply on their livelihoods was palpable. Eventually, the responses came: some amount of electricity daily, with a general consensus of a minimum of eight hours daily. The consistent theme was that any scenario in which there was some electricity supply was preferred over the *status quo*. Some participants asked if it was possible to have uninterrupted power supply, and if there were parts of the world in which power was not rationed, even if only at night.

While these responses indicate the understanding or expectations of gradual landscape change amongst the populace, they were not sufficient for determining the most sustainable vision. Due to the limitations of these visioning exercises, a composite analysis of literature on electricity consumption was used to determine context-specific quantitative short, medium, and long-term goals for electricity consumption.

Quantitative benchmarks for energy poverty are typically computed for the lack of access based on physiological needs and purchasing power for a fixed amount of basic needs in goods and services. Short term changes are defined as occurring within five years, medium term within 10-15 years, and long term within 15-25 years.

For short term benchmarks, this paper uses the UNDP's (2010) estimate of 100 kWh per person annually for lighting, health services, education, and communication devices, in addition to an average of 50 -1000 kgoe[11] of modern fuels and technologies for cooking and heating.

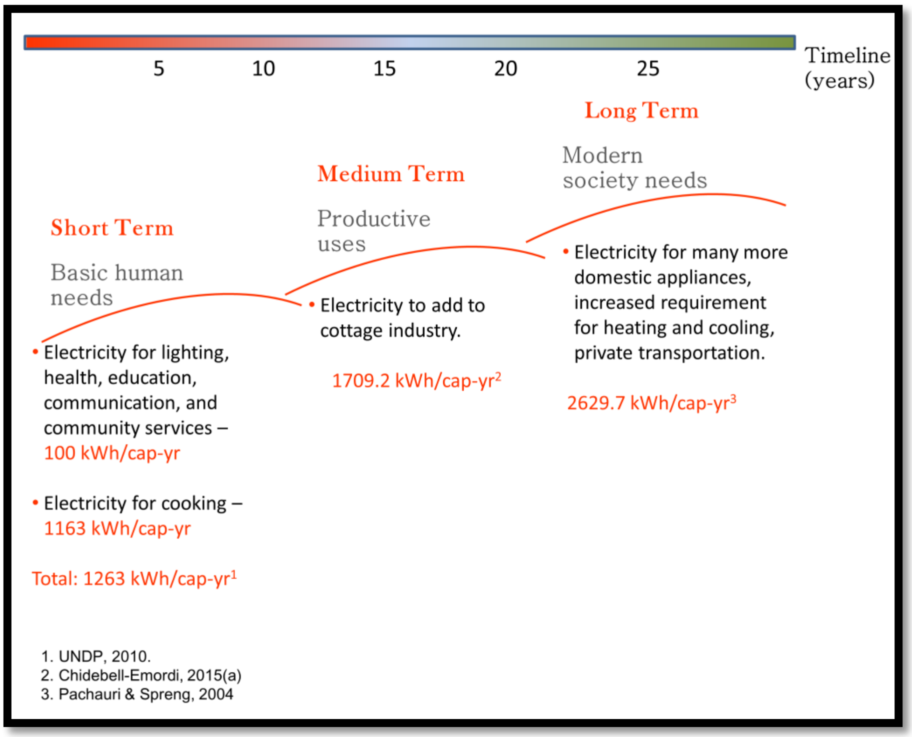

Fig 4.5. Timeline for incremental access to energy services. *Source*: Author

Medium-term benchmarks were based on the electricity consumption patterns of urban southwestern Nigeria at 1709.2 kWh/capita annually (Chidebell-Emordi, 2015(a)). This amount of electricity provides for added value to production in the cottage industry.

[11] Kilogram of oil equivalent; 1 kgoe = 11.63 kWh

Long-term benchmarks were based on direct and indirect energy consumption for a developing nation as proposed by Pachauri & Spreng (2004) at an annual consumption of 2629.7 kWh/capita.

These benchmarks are not meant to be prescriptive but rather suggestive of levels of electrification that are achievable while generation capacity is incrementally attained.

4.4.3 The indicator-based transition management framework

Drawing from previous work done by Sharma & Balachandra (2015), Shortall et al. (2015), and Vithayasrichareon (2012), a multi-level indicator-based framework is proposed to evaluate progress in the transition by specifying indicators in the social, economic, environmental, and institutional dimensions of the electricity system.

The first step in creating the framework is to define short, medium, and long-term goals for electricity consumption per capita. Next, benchmarks for the multi-dimensional indicators within the electricity sector are defined. These benchmarks are threshold countries used as hypothetical frames of reference for best and worst performing. Prior work on electricity sustainability indicators used cross-country comparisons for ASEAN countries (Vithayasrichareon et al., 2012), normative sustainability goals as benchmarks (Schlor et al., 2013), or algorithms for indicator aggregation (Martchamadol & Kumar, 2013). There is no standard baseline or benchmark for electricity sustainability indicators, as such, thresholds can be based on correlating set criteria such as development status, geographical area, or population to name a few.

In addition, all indices are normalized using the equation:

$$\text{Normalized value} = \frac{\text{Indicator value - Minimum threshold value}}{\text{Maximum threshold value - Minumum threshold value}} \qquad \textit{Eqn 1}$$

These indicators are used to create a composite index to evaluate the sustainability of the transition from an energy-poor economy to an energy secure one over the timeline specified.

Social sustainability

Social sustainability quantifies the extent to which electricity is accessible, affordable, equitable, and reliable for the average indigene. Research shows that within urban areas, households have physical connection to the grid; however the state of Nigeria's transmission and distribution infrastructure creates low consumption levels, poor quality of electricity (brownouts[12]), increased household energy costs, and reduced productivity.

Table 4.1. Indicators for measuring social sustainability

Social Sustainability							
Theme	Sub-theme	Indicator	Unit	Indicator value for Country	Threshold Country		Normalized value
					Upper	Lower	
Accessibility		% country electrified	%				
		% urban households electrified	%				
		% rural households electrified	%				
Affordability	Cost	Average tariff	(US c/kWh)				
	Income affordability	Annual consumption (kWh) Lifetime consumption (kWh)					
Adequacy	Availability	Net electricity available	kWh/cap				
	Constancy of supply	Peak shortage	%				
Productivity		Economic productivity (GDP/kWh)	US $PPP/kWh				
		Electricity Intensity in Industrial Sector	US $/kWh				
		Electricity Intensity in Agricultural Sector	US $/kWh				
		Electricity Intensity in Service Sector	US $/kWh				
Acceptability		Quality	%				

[12] The *Acceptability* metric measures the percentage of time daily that the electricity was ±0.5% beyond the normal operating frequency and controls for brownouts.

Table 4.1 shows the indicators and the metric measured. The indicators address these issues and indicate if the electricity system is only meeting basic needs or if it adds value to production to improve livelihoods both at the household-level for cottage industry, or at the *meso*-level, adding to local/regional economic productivity.

Environmental sustainability

Nigeria is the third largest contributor to anthropogenic carbon dioxide emissions from gas flaring, a direct result of its energy sector activities (Marland et al, 2005). These resource-extractive processes increase particulate matter in the air, create environmental degradation from ensuing acid rain, and undermine soil fertility. In addition, of its 21 major power plants in operation, only three produce electricity from renewable sources - hydroelectric power plants (Oyedepo et al., 2014).

The composite indices of environmental sustainability assess the impact of the evolving electricity system on air, land, and water quality. These indicators track changes on the atmosphere in terms of air pollution, as well as water pollution and utilization; low carbon transition in terms of carbon intensity of the national electricity portfolio; and carbon intensity as a direct result of operations in the energy sector.

i. Climate change: CO_2 intensity of generated electricity [kg/kWh]; CO_2 emissions per unit GDP [kg/ US$]; production of electricity from renewables (incl. hydro) [%]
ii. Air /water quality: SO_X [g/kWh]; NO_X [g/kWh]; Particulates[13] (PM10, PM2.5 exceedance) [$\mu g/m^3$]

[13] PM10 and PM2.5 exceedance refer to the size of particulate matter in the air.

iii. Low-carbon transition: % Coal-based generation in electricity portfolio; % natural gas-based generation in electricity portfolio; % growth of renewables capacity in past 5 years.

Economic sustainability

The themes of economic sustainability are quantified in the resource stock, efficiency of generation, transmission, and distribution, and the costs of electricity generation in the form of tariffs and levelized costs from renewable technologies.

Production indicators show trends of market demand and supply for fossil fuels which are exogenous variables that directly affect pricing of electricity, time to depletion of reserves, as well as generation capacity. This is particularly important in a decentralized and privatized system where a distributed system is assumed to make electricity supply and access more sustainable.

Supply indicators are used to track efficiency losses in generation and distribution of electricity while end-use indices reveal changes in electricity consumption in both commercial and non-commercial sectors, an indicator of economic development (Goldemberg et al., 1985). Indicators in the security theme of economic sustainability track short-term and long-term reliability of fuel supply and fuel diversity which guard against price shocks in electricity pricing.

i. Production: R/P[14] for oil, coal, & gas [yrs]; production/consumption for oil, coal, & gas; % increase in generation capacity; renewables capacity/total capacity; % increase in renewables capacity

[14] If the reserves for any fossil fuel are divided by the production rate at that point in time, the result is the length of time the reserves would last if production continued at that rate.

ii. Supply: % losses in transmission and distribution; average thermal efficiency of power plants
iii. End use: % sectoral consumption for residential, agricultural, industry, and commercial and public services; annual household consumption [kWh]; % change in annual household consumption
iv. Security: % reserve margin[15]; fuel diversity for grid [Shannon-Wiener index[16]].

Institutional sustainability

Electricity governance is the cohesive force behind the previously discussed sustainability themes. The themes of institutional sustainability pertain to governance, market dynamics, financing, and access to information.

The governance indices track the existence of energy policy, its regulation and enforcement, level of energy planning, as well as transparency in energy governance institutions. This is important for nations that have modeled their governance institutions after the colonial legacy of the national government as a facilitator for resource extractive activities. In Nigeria, the governance institutions outside of oil and gas production and exportation are weak: the last national energy policy was drafted in 2003 with emphasis on energy production and resource exportation. Language on strategies for regulation, transparency, and enforcement in the energy sector were non-existent, making changes in the deeply ingrained energy governance institutions less likely. As such quantifiable benchmarks are crucial to change these institutions.

---

[15] The reserve margin indicates the difference between the generating capacity of a power plant and anticipated peak loads. If the margin is too low, electricity costs are driven up when demand peaks; if it is too high, capital costs will be lost in power plants that sit idle for long periods of time. The reserve margin is determined by the climate and electricity consumption trends in the region.

[16] The Shannon-Wiener Index is a quantitative measure that computes the strength of diversity of fuel types (in this case). The higher the index, the wider the choice of electricity fuels, and the more buffered the electricity system would be to price shocks.

Market indicators track the business regulatory environment in relation to the ease of doing business and open access. Again, as the most ethnically heterogeneous country on the African continent with 250 distinct ethnic identities (Omotosho, 2014), Nigeria is naturally inclined to experience the network effect in which local and regional electricity administrators establish hereditary claims on administrative offices via patron-client linkages. This leads to a preference for transactions involving multiple intermediaries linked by a chain of personal acquaintances, in essence obfuscating transparency (Hamaguchi, 2012; Fafchamps, 2004). The governance indicators measure change in transparency, from the number of procedures to get an electricity connection, to translation of top-level decisions into practical actions.

Indicators for finance and information access measure access to financing for energy projects as well as data coverage and release of energy statistics and planning documents. The scales indicate a range of values where higher numbers denote an ideal state.

i. Energy sector governance: availability of national energy policy [Scale 1-3]; Extent of implementation of national energy policies [Scale 0-3]; quality of energy planning [Scale 0-3]; Transparency international corruption perception index [0-100]; Getting electricity index [1-189][17];
ii. Competition and market: ease of doing business index [1-189]; status of open access [0-2]; business regulatory environment [0-6].
iii. Financial access: ease of access to financing for energy projects [1-189].
iv. Information access: periodic publications of official energy statistics, documents [1-3]; data coverage [1-3].

[17] Measures the number of procedures, time (days), and cost (as % of income) required to get an electricity connection.

4.5 Discussion and Conclusion

Energy systems are very much context-specific, varying between major economies, developing, and industrializing nations. As such a holistic approach to evaluating the problem, incorporating local perspectives and realities, within the overarching theme of sustainability, is important. In this study we propose an indicator-based transition management strategy encompassing the themes of environmental, social, financial, and institutional sustainability because addressing energy poverty in systems with complex governance institutions resistant to change needs benchmarks to ensure that progress, rather than being subject to the narratives, is measurable.

Privatization of the electricity sector has the potential to decrease the size of the bureaucracy of energy governance and increase legitimacy of leadership since heterogeneity is decreased by decentralizing vertically integrated system of the electricity utility company. This infers that accountability might increase as the distance between the governors and the governed decreases. Thus these indicators can be used as sustainable goals in the transition management strategy.

However, because the data required to populate the indicator tables is dynamic, reliability of in-country generated data is important for the transition to be truly sustainable and for the metrics-based system to be useful. This is a limiting factor due to the paucity of data especially within the themes of environmental and social sustainability: for instance data on carbon intensity of electricity generation depends on the reporting body and might vary widely between the Energy Information Administration, the United Nations Statistics Division, and Nigeria's National Control Center, Osogbo. Some other data, such as "extent of implementation of government policies" and "quality of energy planning" are subjective and as such care must therefore be taken to ensure integrity and consistency of all data.

Finally, it is expected that the countries used as benchmarks for threshold values be at the same or greater level of development and that continuous analysis of the electricity system be conducted to ensure knowledge garnered from strategies, political and economic constraints, as well as conflicts, are incorporated into periodic transition assessment.

Bibilography

1. Abdalla K. L. (1994). Energy policies for sustainable development in developing countries. *Energy Policy, 22*(1), 29-36.

2. Adeyemo, H. (2013). *Challenges Facing Solar Energy projects in Nigeria: A Case Study of Lagos State, Nigeria.*(Thesis). Retrieved from Open Repository of the Universities of Applied Sciences. (10024/1823).

3. Akinbami J.-F.K, Ilori M.O., Oyebisi T.O., Akinwumi I.O., and Adeoti O. (2001). Biogas energy use in Nigeria: current status,future prospects and policy implications. *Renewable and Sustainable Energy Reviews, 5*, 97–112

4. Akinlo A.E. (2009). Electricity consumption and economic growth in Nigeria: Evidence from cointegration and co-feature analysis. *Journal of Policy Modeling, 31,* 681–693

5. Akpabio, E.M. & Akpan, N.S.. (2010). Power supply and environmental sustainability in the University of Uyo: an agenda for full-blown research in Nigeria. *Journal of African Studies Development*, 2(6): 132–143.

6. Alam, M.S., Bala, B.K., Huq, A.M.Z., Matin, M.A., 1991. A model for the quality of life as a function of electrical energy consumption. *Energy 16*(4), 739–745.

7. Alfaro, J. and Miller, S. (2014). Satisfying the rural residential demand in Liberia with decentralized renewable energy schemes. *Renewable and Sustainable Energy Reviews,* 30, 903–911.

8. Alike, E. Lagos, Techno Oil, LCCI, collaborate on cooking gas. THISDAY LIVE. 11 June 2013: web

9. Barnett, A., (2000). Energy and the fight against poverty. Department for International Development (DFID), Livelihood sector report, UK.

10. Bazilian M., Sagar A, Detchon R, Yumkella K. (2010). More heat and light. *Energy Policy. 38*, 5409–12

11. Bekker, B. et al. (2008). South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations. *Energy Policy*, 36, 3125–3137.

12. Berkhout, F. (2006). Normative expectations in systems innovation. *Technol. Anal. Strateg. Manage*, 18, 299–311.

13. Bertaux, D. (1981). *From the life-history approach to the transformation of sociological practice*. In *Biography and society: The life history approach in the social sciences*, ed. by D. Bertaux, 29–45. London: Sage.

14. Brew-Hammond, A. (2010). Energy access in Africa: Challenges ahead. *Energy Policy*, *38*, 2291-2301.

15. Budde B., Alkemade F., Weber M. (2012). Expectations as a key to understanding actor strategies in the field of fuel cell and hydrogen vehicles. *Technological Forecasting and Social Change*, 79, 1059–1071.

16. Büscher B. (2009). Connecting political economies of energy in South Africa. *Energy Policy, 37*(10), 3951-3958.

17. Buzar, S. (2007). The 'hidden' geographies of energy poverty in post-socialism: Between institutions and households. *Geoforum*, *38*(2), 224–240.

18. Capros P., Samouilidis E. (1988). Energy policy analysis. *Energy Policy*, *16*(1), 36-48.

19. Cargo M., and Mercer S. L. (2008). The Value and Challenges of Participatory Research: Strengthening Its Practice. *Annual Review of Public Health*, *29*, 325-350

20. Carmody P. (2009). Cruciform sovereignty, matrix governance and the scramble for Africa's oil: Insights from Chad and Sudan. *Political Geography*, *28*(6), 353-361.

21. Cecelski E. Enabling equitable access to rural electrification: current thinking on energy, poverty and gender. Briefing paper. Asia alternative energy policy and project development support: Emphasis on poverty alleviation and women. Washington DC: Asia Alternative Energy Unit, The World Bank; 2006

22. Chaurey, A., Kandpal, T.C. (2010). Assessment and evaluation of PV based decentralized rural electrification: An overview. *Renewable and Sustainable Energy Reviews*, 14(8), 2266-2278.

23. Chidebell-Emordi, C. (2015). Energy poverty as a cascading result of a failed energy system: A complex systems approach to causation. *Manuscript submitted for publication.*

24. Chidebell-Emordi, C. (2015). The African electricity deficit: Computing the minimum energy poverty line using field research in urban Nigeria. *Energy Research and Social Science, 5*, 9-19. doi:10.1016/j.erss.2014.12.011

25. Clark, W.C. 2007. Sustainability Science: A room of its own. *Proceedings of the National Academy of Science*. *104*, 1737-1738; published online on February 6, 2007, 10.1073/pnas.0611291104

26. Clark, W.C., Dickson, N.M. (2003). Sustainability science: the emerging research programme. *PNAS* 100 (14): 8059–8061.

27. Dortmans, P.J., Eiffe E. (2004). An examination of future scenarios using historical analogy. *Futures,* 36, 1049–1062.

28. Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy*, 11: 147–162.

29. Energy Information Agency (2011). Total Energy Consumption in Nigeria, 2010.

30. Fabowale, Y. (2015, April 30). Ibadan community protests outrageous electricity bills, incessant blackout. *The Sun*. Retrieved from http://sunnewsonline.com/new/ibadan-community-protests-outrageous-electricity-bills-incessant-blackout/

31. Farina, M. F. (2010). Flare Gas Reduction: Recent global trends and policy considerations. GE Energy, Global Strategy and Planning Division.

32. Farla, J. et al. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting & Social Change*, 79, 991–998.

33. Foster, V. & Steinbuks, J. (2009). Paying the price for unreliable power Supplies: In-House generation of electricity by firms in Africa. World Bank Policy Research Paper 4913. April.

34. Fox-Penner, P. (2010). Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities. Island Press, Washington, Covelo, London.

35. Frantzeskaki, N., Loorbach, D. (2010). Towards governing infrasystem transitions: reinforcing lock-in or facilitating change? *Technological Forecasting and Social Change,* 77, 1292–1301.

36. Garcia, S., Moreaux, M., Reynaud, A. (2007). Measuring economies of vertical integration in network industries: An application to the water sector. *Int. J. Ind. Organ. 25*, 791–820

37. Geels, F.E. (2004). From sectoral systems of innovation to socio-technical systems: insights about dynamics and change from sociology and institutional theory. *Research Policy, 33*, 897-920.

38. Geels, F.W., Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy* 36 (3), 399–417.

39. Gibson R.B., S. Hassan, S. Holtz, J. Tansey, and G. Whitelaw (2005). Sustainability Assessment: Criteria and Processes. Earthscan, London.

40. Gibson, R. (2006). Sustainability Assessment: Basic Components of a Practical Approach. *Impact Assessment & Project Appraisal 24*(3), 170-182

41. Gnansounou E., Bayem H., Bednyagin D., and Dong J. (2007). Strategies for regional integration of electricity supply in West Africa. *Energy Policy*, *35*(8), 4142-4153.

42. Goldemberg, J.(1990). One kilowatt per capita. *Bulletin of the Atomic Scientists. 46* (1).

43. Goldemberg, J., Johansson, T.B., Reddy, A.K.N., Williams, R.H. (1985). Basic needs and much more with one kilowatt per capita. *Ambio. 14* (4–5), 190–200.

44. Goldemberg, J., Johansson, T.B., Reddy, A.K.N., Williams, R.H., 1987. Energy for a sustainable world. New Delhi: Wiley-Eastern Limited.

45. Gujbaa H., MulugettaY., Azapagic A. (2010). Environmental and economic appraisal of power generation capacity expansion plan in Nigeria. *Energy Policy. 38*, 5636–5652

46. Haas, R. et al. (2011). A historical review of promotion strategies for electricity from renewable energy sources in EU countries. *Renewable and Sustainable Energy Reviews* 15, 1003–1034.

47. Hadjilambrinos, C. (2000). Understanding technology choice in electricity industries: a comparative study of France and Denmark. *Energy Policy* 28, 1111–1126.

48. Holdren. J. P. (2007). Energy and sustainability. *Science. 315*, 737.

49. Hosier, R. H. (1993). Urban energy systems in Tanzania: A tale of three cities. *Energy Policy. 21*, 510-523.

50. Ikeme, J., and Ebohon, O.J. (2004) Nigeria's electric power sector reform: what should form the key objectives? *Energy Policy. 33*, 1213-1221.

51. International Energy Agency/UN Dev. Program.. (IEA/UNDP/UN IDO). 2010.*Energy Poverty: How to make modern energy access universal?* Special early exerpt of the World Energy Outlook 2010 for the UN General Assembly on the Millineum Development Goals. Retrieved from **http://www.worldenergyoutlook.org/docs/weo2010/weo2010_poverty.pdf**

52. Karekezi, S. (2002). Poverty and energy in Africa – a brief review. *Energy Policy*, 30, 915–919.

53. Kates R. W. and Parris T. M. (2003). Long-term trends and a sustainability transition. *PNAS* 100(14), 8062-8067.

54. Kates, R.W., and Dasgupta, P. (2007). African poverty: A grand challenge for sustainability science. *PNAS*. 104 (43): pp 16747-16750.

55. Kates, R.W., Clark, W.C., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., et al. (2001). Sustainability science. *Science* 292 (5517): 641–642.

56. Kebede B., Bekele A., Kedir E. (2002). Can the urban poor afford modern energy? The case of Ethiopia. *Energy Policy*, *30*(11–12), 1029-1045.

57. Kebede E., Kagochi J., and Jolly C. M. (2010) Energy consumption and economic development in Sub-Sahara Africa. *Energy Economics,* 32(3), 532-537.

58. Khennas S. (2012). Understanding the political economy and key drivers of energy access in addressing national energy access priorities and policies: African Perspective. *Energy Policy*, 47(1), 21-26.

59. Khennas, S. (2012). Understanding the political economy and key drivers of energy access in addressing national energy access priorities and policies: African Perspective. *Energy Policy,* 47, 21–26.

60. Kieffer, S.W., Barton, P., Palmer, A.R., Reitan, P.H., & Zen, E. 2003. Megascale events: Natural disasters and human behavior. *Geol. Soc. America* Abstracts with programs: 432.

61. Komiyama, H., Takeuchi, K. (2006). Sustainability science: building a new discipline. *Sustainability Science*, 1 (1): 1–6.

62. Krugman, H. and Goldemberg, J. (1983): 'The energy cost of satisfying basic human needs', *Technological Forecasting and Social Change*, 24, 45-60.

63. Lior N. (2012). Sustainable energy development: The present (2011) situation and possible paths to the future. *Energy*, 43(1), 174-191.

64. Litosseliti, L. (2003). Using focus groups in research, Cornwall: Continuum.

65. Maclaren V.W. (1996). Urban Sustainability Reporting. *Journal of the American Planning Association*, 62(2):184-202.

66. Marland, G., T.A. Boden, and R. J. Andres. (2005). *Global, regional, and national CO_2 emmissions. Trends: A Compendium of Data on Global Change*, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

67. Martchamadol J, Kumar S. (2013). An aggregated energy security performance indicator. *Applied Energy*, 10, 653–70.

68. Meagher, K., & Mohammed-Bello, Y. United Nations Research Institute for Social Development. The Social Effects of Globalization. Passing the Buck: Structural Adjustment and the Nigerian Urban Informal Sector. Geneva: UN 1996.

69. Mihelcic, J.R, et al., 2003, Sustainability Science and Engineering: The Emergence of a New Metadiscipline. *Environmental Science & Technology*, 37(23): 5314-5324.

70. Mimmi, L.M. (2014). From informal to authorized electricity service in urban slums: Findings from a household level survey in Mumbai. *Energy for Sustainable Development*, 21, 66–80.

71. Modi V, McDade S, Lallement D, Saghir J. (2005). Energy services for the millennium development goal. Millennium Project: UNDP. The World Bank and Energy Sector Management Assistance Program (ESMAP), pp. 2e4.

72. Mohammed, Y.S. et al. (2013). An overview of agricultural biomass for decentralized rural energy in Ghana. *Renewable and Sustainable Energy Reviews*, 20, 15-25.

73. Moseley W. G. (2001). African evidence on the relation of poverty, time preference and the environment. *Ecological Economics*, 38(3), 317-326.

74. NEPAD. (2001). The New Partnership for Africa's Development. New Partnership for Africa's Development (NEPAD), Pretoria, South Africa.

75. Nigerian National Energy Policy. Federal Republic of Nigeria. 2003.

76. Nigerian Research Institutes. Nigeria Master Web. Retrieved from http://nigeriamasterweb.com/ResearchInsts.html on 04/05/2013.

77. Normann, H.E. (2015). The role of politics in sustainable transitions: The rise and decline of offshore wind in Norway. *Environmental Innovation and Societal Transitions*, 15, 180–193.

78. Nussbaumer, M. C. and Sen, A. (1993). The Quality of Life, Oxford: Clarendon Press.

79. Oakerson, R. J. and Parks, R. B. (2011). The Study of Local Public Economies: Multi-organizational, Multi-level Institutional Analysis and Development. *Policy Studies Journal,* 39(1), 147–167.

80. Ogbogbo, C.B.N. (2004) "The Beginning of the Oil Industry in Nigeria1906-1956" *Quill pen 4*, 1-9

81. Oirere, S. Lenders and leading developer focus on Nigerian market. PV Magazine 8 August 2014: web.

82. Okoro, O.I, & Chikuni, E. (2007). Power sector reforms in Nigeria: opportunities and challenges. *Journal of Energy in Southern Africa*, 18(3): 52-57.

83. Oni, A. (2012, August 9). The PIB, Gas and the Nigerian Electricity Supply Industry. *Business Day*. Retrieved from http://businessdayonline.com/NG/index.php/law/cover/42510-the-pib-gas-and-the-nigerian-electricity-supply-industry.

84. Oseni, M.O. (2012). Households' access to electricity and energy consumption pattern in Nigeria. *Renewable and Sustainable Energy Reviews, 16*, 990–995

85. Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Science*. 104, 15181-15187.

86. Oyedepo S. O. (2012). On energy for sustainable development in Nigeria. *Renewable and Sustainable Energy Reviews*, 16(5), 2583-2598.

87. Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, **2**:15.

88. Pachauri, S., & Spreng,D. (2011). Measuring and monitoring energy poverty. *Energy Policy*. 39, 7497-7504.

89. Pandey R. (2001). Energy policy modelling: agenda for developing countries. *Energy Policy,* 30(2), 97-106.

90. Parag, Y. and Janda, K.B. (2010). More than filler: Middle actors and socio-technical change in the energy system from the "middle-out". *Energy Research & Social Science,* 3, 102–112.

91. Parajuli, R. (2011). Access to energy in Mid/Far west region-Nepal from the perspective of energy poverty. *Renewable Energy* 36, 2299-2304.

92. Pereiraa, M. G., Freitasa, M. A. V., and Da Silvaa, N. F. (2011). The challenge of energy poverty: Brazilian case study. *Energy Policy*, 39(1), 167–175.

93. Peters J., Harsdorff M., Ziegler F. (2009). Rural electrification: Accelerating impacts with complementary services. *Energy for Sustainable Development*, 13(1), 38-42.

94. Port From Kerosene, Firewood To Gas, Fashola Urges Lagosians. *Channels TV*. (2013, June 13) Retrieved from http://www.channelstv.com/home/2013/06/11/port-from-kerosenefirewood-to-gas-fashola-urges-lagosians/

95. Practical Action. (2008). Energy poverty: Estimating the level of energy poverty in Sri Lanka.

96. Reitan, P. (2005). Sustainability science – and what's needed beyond science. *Sustainability: Science, Practice, & Policy* 1(1):77-80.

97. Rip, A., Kemp, R. (1998). *Technological change*. In: Rayner, S., Malone, E.L. (Eds.), *Human Choice and Climate Change – Resources and Technology*. Battelle Press, Columbus, pp. 327–399.

98. Rockstrom J, et al. (2009). A safe operating space for humanity. *Nature*, 461, 472-475.

99. Rosenbloom, D., and Meadowcroft, J. (2014). The journey towards decarbonization: Exploring socio-technical transitions in the electricity sector in the province of Ontario (1885–2013) and potential low-carbon pathways. *Energy Policy,* 65, 670–679.

100. Rotmans, J., Kemp, R., van Asselt, M. (2001). More Evolution than Revolution; Transition Management in Public Policy. *Foresight*, 03(1), 15-31 .

101. Sagar, A.D. (2005) Alleviating energy poverty for the world's poor. *Energy Policy*, 33(11), 1367-1372.

102. Saldana J (2009) The coding manual for qualitative researchers. SAGE, Los Angeles.

103. Sambo A. S., Garba B., Zarma I. H. and GajiM. M. (2009). Electricity Generation and the Present Challenges in the Nigerian Power Sector. *World Energy Council*.

104. Schäfer, M., Kebir, N., and Neumann, k. (2011). Research needs for meeting the challenge of decentralized energy supply in developing countries. *Energy for Sustainable Development*, 15, 324–329.

105. Schlör H, Fischer W, & Hake J. (2013). Methods of measuring sustainable development of the German energy sector. *Applied Energy*, 101, 172–81.

106. Schuitmaker, T.J. (2012). Identifying and unravelling persistent problem. *Technological Forecasting and Social Change* 79, 1021–1031.

107. Sgouridis, S. et al. (2013). A sustainable energy transition strategy for the United Arab Emirates: Evaluation of options using an Integrated Energy Model. *Energy Strategy Reviews*, 2, 8-18.

108. Siddayao C. M. (1998). Energy policy issues in developing countries Lessons from ASEAN's experience. *Energy Policy,* 16(6), 608-620.

109. Skjærseth J. B., Tangen K., Swanson P., Christiansen A. C., Moe A., and Lunde L. (2004). Limits to Corporate Social Responsibility: A comparative study of four major oil companies. Fridtjof Nansen Institute, Norway.

110. Smith A. (2007). Emerging in between: the multi-level governance of renewable energy in the English regions. *Energy Policy*, 35(12):6266–80.

111. Sokona Y., Mulugetta Y., and Gujba H. (2012). Widening energy access in Africa: Towards energy transition. *Energy Policy,* 47(1), 3-10.

112. Sonibare, J.A., and Akeredolu F.A. (2006). Natural gas domestic market development for total elimination of routine flares in Nigeria's upstream petroleum operations. *Energy Policy*. Vol. 34, pp. 743-753.

113. Spencer H. (1897). *First Principles*. New York: Appleton

114. Steinbuks, J. & Foster, V. (2010). When do firms generate? Evidence on in-house electricity supply in Africa. *Energy Economics*, 32, 505–514.

115. Stephens, J.C., Jiusto, S. (2010). Assessing innovation in emerging energy technologies: socio-technical dynamics of carbon capture and storage (CCS) and enhanced geothermal systems (EGS) in the USA. *Energy Policy* 38, 2020–2031

116. Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Thousand Oaks, CA: Sage.

117. Swart RJ, Raskin P, Robinson J. (2004). The problem of the future—Sustainability science and scenario analysis. *Global Environ Change, 14,* 137-146.

118. The White House, Office of the Press Secretary. (2013). Making Energy More Accessible in Africa: The Power Africa Off-Grid Energy Challenge [Press release]. Retrieved from https://www.whitehouse.gov/blog/2013/09/24/making-energy-more-accessible-africa-power-africa-grid-energy-challenge

119. Tinashe D. N. (2007). Electricity sector reform in Mozambique: a projection into the poverty and social impacts. *Journal of Cleaner Production*, 15(2), 190-202.

120. Toman, M., Lemelkova, B. (2003). Energy and economic development: an assessment of the state of knowledge. *The Energy Journal*, *24* (4).

121. UNDP, 2010. Energy for a Sustainable Future. The Secretary-General's Advisory Group On Energy And Climate Change (AGECC) Summary Report and Recommendations, Washington, DC.

122. UNDP/WB, 2003. Household energy use in developing countries. A multi country study. Energy Sector Management Assistance Program (ESMAP) of the UNDP and World Bank. Washington, DC.

123. Unruh G.C. (2000). Understanding carbon lock-in. *Energy Policy*, 28(12): 817–30.

124. Urban, F., Benders, R.M.J., Moll, H.C. (2007). Modelling energy systems for developing countries. *Energy Policy*, *35*, 3473-3482.

125. Van der Schoor, Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews*, 43, 666–675.

126. Verbong, G., and Geels, F. (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy,* 35, 1025–1037.

127. Vithayasrichareon P, MacGill IF, Nakawiro T. (2012). Assessing the sustainability challenges for electricity industries in ASEAN newly industrializing countries. *Renewable Sustainable Energy Reviews*, 16, 2217–33.

128. Wiek, A., and Childers, D. L. (2010). Crafting science-based solutions for sustainability problems in complex social- ecological systems. *PNAS*, (March).

129. Wiek, A., Ness, B., Brand, F.S., Schweizer-Ries, P., & Farioli, F. (2012). From complex systems analysis to transformational change: A comparative appraisal of sustainability science projects. *Sustainability Science, 7(1),* 5-24

130. Wilkinson, R., Cary, J. (2002). Sustainability as an evolutionary process. *International Journal of Sustainable Development*, 5, 381–391.

131. Wolde-Rufael, Y. (2005). Energy demand and economic growth: The African experience. *Journal of Policy Modeling*, 27, 891–903

132. Yeager, K. (2001). Electricity development for a sustainable world: bridging the digital divide. *World Energy Council 18th* Congress-Buenos Aires.

COMPREHENSIVE BIBLIOGRAPHY

1. Abdalla K. L. (1994). Energy policies for sustainable development in developing countries. *Energy Policy, 22*(1), 29-36.

2. Abdullah, S., & Markandya, A. (2012). Rural electrification programmes in kenya: Policy conclusions from a valuation study. *Energy for Sustainable Development, 16*(1), 103-110. doi:10.1016/j.esd.2011.10.007.

3. Abiodun, J.O., 1997. The challenges of growth and development in metropolitan Lagos, in: Rakodi, C. The urban challenge in Africa: growth and management of Its large cities. United Nations University.

4. Acemoglu, D., S. Johnson and J. A. Robinson (2001), The Colonial Origins of Comparative Development: An Empirical Investigation', *American Economic Review*, 91,1369–1401.

5. Adam Smith International. (2013, September 23). The light is getting brighter in Nigeria. The Guardian. Retrieved from http://www.theguardian.com/global-development-professionals-network/adam-smith-international-partner-zone/nigeria-power-electricity-africa.

6. Adegbulugbe, T. A., Bello, R. S., & Oniyire, S. O. (2015). Investigation into industrial generator maintenance culture in agro-based industries in ibadan, south-west nigeria.*Agricultural Engineering International: CIGR Journal, 17*(2), 39-44. Retrieved from www.scopus.com

7. Adenuga, O. A., Odusami, K. T., & Faremi, J. O. (2007). Assessment of factors affecting maintenance management of public hospital buildings in lagos state, nigeria. Paper presented at the *Construction and Building Research Conference of the Royal Institution of Chartered Surveyors, COBRA 2007,*

8. Adeyemo, H. (2013). *Challenges Facing Solar Energy projects in Nigeria: A Case Study of Lagos State, Nigeria.*(Thesis). Retrieved from Open Repository of the Universities of Applied Sciences. (10024/1823).

9. Adeyeri, M. K., Kareem, B., Ayodeji, S. P., & Emovon, I. (2011). Dynamic maintenance strategy, the panacea to materials wastage from machinery. Paper presented at the*Proceedings of the World Congress on Engineering 2011, WCE 2011, , 1* 691-695. Retrieved from www.scopus.com

10. Ahenda, A.O. (2015). *A shift in mental models processing: A systems approach*. In M, Muchie, V. Gumede, P. Lukhele-Olorunju (Eds.), *Unite or Perish: Africa Fifty Years after the Founding of the OAU* (pp. 163-175).Africa Institute of South Africa.

11. Ahlborg, H., & Sjöstedt, M. (2015). Small-scale hydropower in africa: Socio-technical designs for renewable energy in tanzanian villages. *Energy Research and Social Science, 5*, 20-33. doi:10.1016/j.erss.2014.12.017

12. Ajayi, O.O., 2010. The potential for wind energy in Nigeria. *Wind Engineering,* 34 (3), 303–312.

13. Ajugwo, A.O., 2013. Negative effects of gas flaring: the Nigerian experience. *J. Env Pollutn and Hum Hlth*, 1(1), 6-8.

14. Ake, C. (1996). *Democracy and Development in Africa*. Washington, DC: The Brookings Institution.

15. Akinbami J.-F.K, Ilori M.O., Oyebisi T.O., Akinwumi I.O., and Adeoti O., 2001. Biogas energy use in Nigeria: current status, future prospects and policy implications. *Renewable and Sustainable Energy Reviews, 5*, 97–112

16. Akinbami, J.F.K., 1994. Forestry, development and environment - the energy connection: Nigeria case study. *Renewable Energy*, 5(5), 770-773.

17. Akinbulire, T. O., Oluseyi, P. O., & Babatunde, O. M. (2014). Techno-economic and environmental evaluation of demand side management techniques for rural electrification in ibadan, nigeria. *International Journal of Energy and Environmental Engineering, 5*(4), 375-385. doi:10.1007/s40095-014-0132-2.

18. Akinlo A.E. (2009). Electricity consumption and economic growth in Nigeria: Evidence from cointegration and co-feature analysis. *Journal of Policy Modeling, 31,* 681–693

19. Akinosho, T. (2013, October 22). Nigeria Commissions Thermal Plants Without Fuel Supply. Africa oil and gas report. Retrieved from http://africaoilgasreport.com/2013/10/gas-monetization/nigeria-commissions-thermal-plants-without-fuel-supply/

20. Akinsanmi, O., Ekundayo, K. R., & Okorie, P. U. (2013). *Reliability assessment of an electronic system: A case study of nokia N1650 mobile phone charger in zaria, nigeria*doi:10.4028/www.scientific.net/AMR.824.170

21. Akpabio, E.M. & Akpan, N.S.. (2010). Power supply and environmental sustainability in the University of Uyo: an agenda for full-blown research in Nigeria. *Journal of African Studies Development*, 2(6): 132–143.

22. Alam, M.S., Bala, B.K., Huq, A.M.Z., Matin, M.A., 1991. A model for the quality of life as a function of electrical energy consumption. *Energy 16*(4), 739–745.

23. Alamba, S. (2011, July 22). *Nigeria Power employee works on a tangle of lines.* [digital image]. Retrieved from http://www.voanews.com/content/nigeria_power_capacity_poverty_oil_electrical_access/1447395.html

24. Alesina, Alberto, and Enrico Spolaore. (1997). On the Number and Size of Nations. *Quarterly Journal of Economics*, 112: 1027-1056.

25. Alesina, Alberto, et al. *Public Goods and Ethnic Divisions*. Harvard University and World Bank mimeo, March 1997.

26. Alfaro, J. and Miller, S. (2014). Satisfying the rural residential demand in Liberia with decentralized renewable energy schemes. *Renewable and Sustainable Energy Reviews,* 30, 903–911.

27. Alhassan, D. A., Ahmed, Y. B., & Ugwu, F. C. (2012). Privatization: A policy to transform and increase the production capacity of fish in nigeria fish industries. *Journal of Fisheries and Aquatic Science, 8*(1 SPL. ISS.), 26-29. doi:10.39231jfas.2013.26.29

28. Alike, E. Lagos, Techno Oil, LCCI, collaborate on cooking gas. THISDAY LIVE. 11 June 2013: web

29. Allot, A. N. (1978). Nigeria: Land Use Decree, 1978. *Journal of African Law*, 22(2): 136-160.

30. Amara, J. I. (2009). Mixed culture in maintenance facilities in nigeria. Paper presented at the *Proceedings of the Flight Safety Foundation Annual International Air Safety Seminar, International Federation of Airworthiness International Conference, and the International Air Transport Association, , 1* 589-619. Retrieved from www.scopus.com

31. Andreski, S. (1968).*The African Predicament*, London: Michael & Joseph, 1968.

32. Anyanwu, C.M., 2004. Microfinance Institutions in Nigeria: Policy, Practice and Potentials. Presentation. G24 Workshop 29th November, 2004.

33. Asaju, K., 2010. Local government autonomy in Nigeria: politics and challenges of the 1999 constitution. *Intl Jnl of Adv Legal Stud and Govnce*, 1(1), 89-113.

34. Awofeso, N. (2011). Generator diesel exhaust: A major hazard to health and the environment in nigeria. *American Journal of Respiratory and Critical Care Medicine, 183*(10), 1437.

35. Barnett, A., (2000). Energy and the fight against poverty. Department for International Development (DFID), Livelihood sector report, UK.

36. Barrett, C.B., and Swallow, B.M. (2006). Fractal Poverty Traps. *World Development*. *34*(1), 1–15.

37. Basedau, M., & Lay, J. (2005). Conceptualising the 'Resource Curse'in Sub-Saharan Africa: Affected Areas and Transmission Channels. *Resource Politics in Sub-Saharan Africa*, 9-24.

38. Bates, R. H. (2000). Ethnicity and development in Africa: A reappraisal. *American Economic Review* 90: 131-34.

39. Bazilian M., Sagar A, Detchon R, Yumkella K. (2010). More heat and light. *Energy Policy. 38*, 5409–12

40. Bekker, B. et al. (2008). South Africa's rapid electrification programme: Policy, institutional, planning, financing and technical innovations. *Energy Policy*, 36, 3125–3137.

41. Bello, S.L. (2013). Evaluating the Methodology of Setting Electricity Prices in Nigeria. *International Association for Energy Economics.*4th Quarter, 33-34.

42. Berkhout, F. (2006). Normative expectations in systems innovation. *Technol. Anal. Strateg. Manage*, 18, 299–311.

43. Bertaux, D. (1981). *From the life-history approach to the transformation of sociological practice*. In *Biography and society: The life history approach in the social sciences*, ed. by D. Bertaux, 29–45. London: Sage.

44. Bhattacharyya, S.C., and Timilsina, G.R., 2009. Energy demand models for policy formulation: A comparative study of energy demand models. The World Bank Development Research Group, Environment and Energy team.

45. Blum, A. L., & Langley, P. (1997). Selection of relevant features and examples in machine learning. *Artificial Intelligence, 97*(1-2), 245-271.

46. Boardman, B., 1991. Fuel poverty: From cold homes to affordable warmth. London: Belhaven Press.

47. Boone, C. (1994). *States and ruling classes in postcolonial Africa: the enduring contradictions of power*. In J. Migdal, A. Kohli, & V. Shue (Eds.), *State power and social forces: domination and transformation in the Third World* (pp. 108–139). New York: Cambridge University Press.

48. Bouzarovski, S., & Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty-fuel poverty binary. *Energy Research and Social Science, 10*, 31-40. doi:10.1016/j.erss.2015.06.007

49. Brew-Hammond, A. (2010). Energy access in Africa: Challenges ahead. *Energy Policy*, *38*, 2291-2301.

50. Brown, D. (2000). Democracy, colonization, and human capital in sub-Saharan Africa. *Studies in Comparative International Development*, 35(1), 20–40.

51. Budde B., Alkemade F., Weber M. (2012). Expectations as a key to understanding actor strategies in the field of fuel cell and hydrogen vehicles. *Technological Forecasting and Social Change*, 79, 1059–1071.

52. Bugaje, I.M., 2006. Renewable energy for sustainable development in Africa: a review. *Ren and Sust Energy Rev*, 10(6), 603-612.

53. Büscher, B. (2009). Connecting political economies of energy in South Africa. *Energy Policy, 37*(10), 3951-3958. doi:10.1016/j.enpol.2009.04.041

54. Buzar, S. (2007). The 'hidden' geographies of energy poverty in post-socialism: Between institutions and households. *Geoforum*, *38*(2), 224–240.

55. Capros P., Samouilidis E. (1988). Energy policy analysis. *Energy Policy*, *16*(1), 36-48.

56. Cargo M., and Mercer S. L. (2008). The Value and Challenges of Participatory Research: Strengthening Its Practice. *Annual Review of Public Health*, *29*, 325-350

57. Carmody P. (2009). Cruciform sovereignty, matrix governance and the scramble for Africa's oil: Insights from Chad and Sudan. *Political Geography*, *28*(6), 353-361.

58. Caselli, F., Cunningham, T. (2007). Political decision making in resource abundant countries, Paper prepared for the OxCarre launch conference, December 2007.

59. Cecelski E. Enabling equitable access to rural electrification: current thinking on energy, poverty and gender. Briefing paper. Asia alternative energy policy and project development support: Emphasis on poverty alleviation and women. Washington DC: Asia Alternative Energy Unit, The World Bank; 2006

60. Central Intelligence Agency, 2013. "Nigeria." Cia.gov Central Intelligence Agency, n.d. Web 14 Dec. 2013.

61. Chaurey, A., Kandpal, T.C. (2010). Assessment and evaluation of PV based decentralized rural electrification: An overview. *Renewable and Sustainable Energy Reviews*, 14(8), 2266-2278.

62. Chaurey, A., Ranganathan, M., Mohanty, P., 2004. Electricity access for geographically disadvantaged rural communities—technology and policy insights. *Energy Policy*. 32(15), 1693-1705.

63. Chidebell-Emordi, C. (2015). Energy poverty as a cascading result of a failed energy system: A complex systems approach to causation. *Manuscript submitted for publication.*

64. Chidebell-Emordi, C. (2015). The African electricity deficit: Computing the minimum energy poverty line using field research in urban Nigeria. *Energy Research and Social Science, 5*, 9-19. doi:10.1016/j.erss.2014.12.011

65. Chidebell-Emordi, C. (2015). The African electricity deficit: Computing the minimum energy poverty line using field research in urban Nigeria. *Energy Research and Social Science, 5*, 9-19. doi:10.1016/j.erss.2014.12.011

66. Clapham, C. (1982). *The politics of failure: Clientelism, political instability and national integration in Liberia and Sierra Leone.* In C. Clapham (Ed.), Private patronage and public power (pp. 71–97). New York: St. Martin's Press.

67. Clark, W.C. 2007. Sustainability Science: A room of its own. *Proceedings of the National Academy of Science*. *104*, 1737-1738; published online on February 6, 2007, 10.1073/pnas.0611291104

68. Clark, W.C., Dickson, N.M. (2003). Sustainability science: the emerging research programme. *PNAS* 100 (14): 8059–8061.

69. Cohen, B., 2006. Urbanization in developing countries: Current trends, future projections, and key challenges for sustainability. *Technology in Society* 28 (2006) 63–80.

70. Colenbrander, S., Lovett, J., Abbo, M.S., Msigwa, C., Mabiala, B.M., and Opoku, R. (2015). Renewable energy doctoral programs in sub-Saharan Africa: a preliminary assessment of common capacity deficits and emerging capacity building strategies. *Energy Research and Social Science*. 5,

71. Connors, W. (2009, April 25). Nigeria Moves to Address Chronic Power Outages. *The Wall Street Journal*. Retrieved from http://www.wsj.com/articles/SB124062314911155519

72. Coutard O, Guy S. (2007). STS and the city: politics and practices of hope. *Sci Technol Hum Values*; 32(6):713–34.

73. Dagoumasa,A., Kitsios, K. (2014). Assessing the impact of the economic crisis on energy poverty in Greece. *Sustainable Cities and Society,* 13: 267–278.

74. Damania, R., Bulte, E. (2003). Resources for sale: Corruption, democracy and the natural resource curse, Discussion Paper no. 0320, Centre for International Economic Studies, University of Adelaide.

75. Dambazau, A. (2014). Nigeria and Her Security Challenges. *Harvard International Review,* 35(4):65-70.

76. Davis, M., 1998. Rural household energy consumption: The effects of access to electricity—evidence from South Africa. *Energy Policy*. 26(3), 207-217.

77. Dibue, J.I. (2006*). Modernization and the Crisis of Development in Africa: The Nigerian Experience*. Hampshire: Ashgate Publishing Company.

78. Dike, A. (1983). Land Tenure System in Igboland. *International Review of Ethnology and Linguistics. Anthropos,* 78: 853-871.

79. Dortmans, P.J., Eiffe E. (2004). An examination of future scenarios using historical analogy. *Futures,* 36, 1049–1062.

80. Dosi, G. (1982). Technological paradigms and technological trajectories. *Research Policy*, 11: 147–162.

81. Akpabio E.M. & Akpan N.S.. (2010). Power supply and environmental sustainability in the University of Uyo: an agenda for full-blown research in Nigeria. *Journal of African Studies Development*, 2(6): 132–143.

82. Eme Ichoku, H., Fonta, W. M., & Ataguba, J. E. (2013). Political economy and history: Making sense of health financing in sub-Saharan Africa. *Journal of International Development, 25*(3), 297-309. doi:10.1002/jid.2842

83. Energy Information Agency (2011). Total Energy Consumption in Nigeria, 2010.

84. Energy Information Agency. (2013). Country Briefs: Nigeria. Retrieved from http://www.eia.gov/countries/analysisbriefs/Nigeria/nigeria.pdf.

85. Englebert P, Tarango S and Carter M (2002) Dismemberment and suffocation: A contribution to the debate on African boundaries. *Comparative Political Studies* 35(10): 1093–118.

86. Englebert, P. (2000). Pre-colonial institutions, post-colonial states, and economic development in tropical Africa. *Political Research Quarterly* 53, 7 – 36.

87. Epstein, M. (1913). *Statemans Year Book*. London: Macmillian and Co., 64th Ed, 1949. Available online: http://catalog.hathitrust.org/Record/008883627

88. Eyitayo, S. A. (2011). Book, technology and infrastructural development: What the future holds for the book industry in nigeria. *Publishing Research Quarterly, 27*(3), 277-287. doi:10.1007/s12109-011-9230-7

89. Fabowale, Y. (2015, April 30). Ibadan community protests outrageous electricity bills, incessant blackout. *The Sun*. Retrieved from http://sunnewsonline.com/new/ibadan-community-protests-outrageous-electricity-bills-incessant-blackout/

90. Fafchamps, M. (2004). *Market institutions in Sub-Saharan Africa.* Cambridge, MA: MIT Press.

91. Faleyimu, O.I., Akinyemi, O., Agbeja, B.O., 2010. Incentives for forestry development in the southwest Nigeria. *African Jnl of Gen Agric*. 6(2), 67-76.

92. Farina, M. F. (2010). Flare Gas Reduction: Recent global trends and policy considerations. GE Energy, Global Strategy and Planning Division.

93. Farla, J. et al. (2012). Sustainability transitions in the making: A closer look at actors, strategies and resources. *Technological Forecasting & Social Change*, 79, 991–998.

94. Faruqui A, Sergici S, and Sharif A. (2010). The impact of informational feedback on energy consumption – a survey of the experimental evidence. *Energy,* 35:1598–608.

95. Federal Republic of Nigeria. (2001). A Blueprint for the Schema of National Poverty Eradication Program (NAPEP), Abuja.

96. Foster, J. (2005). From simplistic to complex systems in economics. *Cambridge Journal of Economics*, 29: 873-892.

97. Foster, V. & Steinbuks, J. (2009). Paying the price for unreliable power Supplies: In-House generation of electricity by firms in Africa. World Bank Policy Research Paper 4913. April.

98. Fox-Penner, P. (2010). Smart Power: Climate Change, the Smart Grid, and the Future of Electric Utilities. Island Press, Washington, Covelo, London.

99. Frantzeskaki, N., Loorbach, D. (2010). Towards governing infrasystem transitions: reinforcing lock-in or facilitating change? *Technological Forecasting and Social Change,* 77, 1292–1301.

100. Fukuyama, F., & Fukuyama, F. (2014). Political order and political decay: From the industrial revolution to the globalization of democracy.

101. Garcia, S., Moreaux, M., Reynaud, A. (2007). Measuring economies of vertical integration in network industries: An application to the water sector. *Int. J. Ind. Organ. 25*, 791–820

102. Garside, B. (2011, February 24). Power and politics in Nigeria. *International Institute for Environment and Development*. Retrieved from http://www.iied.org/power-politics-nigeria

103. Garside, B. (2012, January 27). Privatising Nigeria's power sector. *International Institute for Environment and Development*. Retrieved from http://www.iied.org/privatising-nigeria-s-power-sector

104. Geels, F. W. (2004). From sectoral systems of innovation to socio-technical systems: Insights about dynamics and change from sociology and institutional theory. *Research Policy, 33*(6-7), 897-920. doi:10.1016/j.respol.2004.01.015

105. Geels, F.W., Schot, J. (2007). Typology of sociotechnical transition pathways. *Research Policy* 36 (3), 399–417.

106. Geschiere, P. (1993). Chiefs and Colonial Rule in Cameroon: Inventing Chieftaincy, French and British Style . *Africa: Journal of the International African Institute, 63(* 2), 151-175.

107. Gibson R.B., S. Hassan, S. Holtz, J. Tansey, and G. Whitelaw (2005). Sustainability Assessment: Criteria and Processes. Earthscan, London.

108. Gibson, R. (2006). Sustainability Assessment: Basic Components of a Practical Approach. *Impact Assessment & Project Appraisal 24*(3), 170-182

109. Gnansounou E., Bayem H., Bednyagin D., and Dong J. (2007). Strategies for regional integration of electricity supply in West Africa. *Energy Policy*, *35*(8), 4142-4153.

110. GoI, 2001. Resolutions of the Chief Ministers/Power Ministers Conference on 3rd March, 2001.

111. Goldemberg, J.(1990). One kilowatt per capita. *Bulletin of the Atomic Scientists. 46* (1).

112. Goldemberg, J., Johansson, T.B., Reddy, A.K.N., Williams, R.H. (1985). Basic needs and much more with one kilowatt per capita. *Ambio. 14* (4–5), 190–200.

113. Goldemberg, J., Johansson, T.B., Reddy, A.K.N., Williams, R.H. (1987). Energy for a sustainable world. New Delhi: Wiley-Eastern Limited.

114. Goldsmith, A. A. (2001). Risk, rule, and reason in Africa: Leadership in Africa. *Public Administration and Development*, 21(2), 77-87.

115. Goldthau, A. (2014). Rethinking the governance of energy infrastructure: Scale, decentralization and polycentrism. *Energy Research and Social Science, 1*, 134-140. doi:10.1016/j.erss.2014.02.009.

116. Grabowski, R. (2006). Political development, agriculture, and ethnic divisions: An african perspective. *African Development Review, 18*(2), 163-182. doi:10.1111/j.1467-8268.2006.00137.x

117. Green, E. (2013). Explaining african ethnic diversity. *International Political Science Review, 34*(3), 235-253. doi:10.1177/0192512112455075

118. Grier, R. (1999). Colonial legacies and economic growth. *Public Choice*, 98(3–4), 317–335.

119. Groh, S. (2014). The role of energy in development processes—The energy poverty penalty: Case study of Arequipa (Peru). *Energy for Sustainable Development,* 18: 83–99.

120. Gujbaa H., MulugettaY., Azapagic A. (2010). Environmental and economic appraisal of power generation capacity expansion plan in Nigeria. *Energy Policy. 38*, 5636–5652

121. Gunningham, N. (2013). Managing the energy trilemma: The case of Indonesia. *Energy Policy*, 54: 184–193.

122. Haas, R. et al. (2011). A historical review of promotion strategies for electricity from renewable energy sources in EU countries. *Renewable and Sustainable Energy Reviews* 15, 1003–1034.

123. Hadjilambrinos, C. (2000). Understanding technology choice in electricity industries: a comparative study of France and Denmark. *Energy Policy* 28, 1111–1126.

124. Hall, D. (2007). Energy privatization and reform in East Africa. Public Services International Research Unit (PSIRU), University of Greenwich, 12 January.

125. Hamaguchi, N. (2012). *Evidence from spatial correlation of poverty and income in Kenya* doi:10.1017/CBO9781139198998.011

126. Handley, G. et al. (2009). Poverty and Poverty Reduction in Sub-Saharan Africa: An Overview of Key Issues. Working Paper 299. Overseas Development Institute. Retrieved from http://www.odi.org/sites/odi.org.uk/files/odi-assets/publications-opinion-files/860.pdf

127. Herendeen, R., Ford, C., Hannon, B., 1981. Energy cost of living, 1972–73. *Energy* 6 (12), 1433–1450.

128. Hino, H. (2012). *Ethnic diversity and economic instability in Africa: Interdisciplinary perspectives*. Cambridge, UK ; New York: Cambridge University Press.

129. Holdren. J. P. (2007). Energy and sustainability. *Science. 315*, 737.

130. Hosier, R. H. (1993). Urban energy systems in Tanzania: A tale of three cities. *Energy Policy. 21*, 510-523.

131. Hove, M. et al. (2013). The Urban Crisis in Sub-Saharan Africa: A Threat to Human Security and Sustainable Development. *Stability*, 2(1): 7, pp 1-14.

132. Howells, M., Solomon, M., Bennett, K., Kenny, A., 2002. Energy Outlook for South Africa 2002. National IEP, Energy Research Institute, University of Cape Town.

133. Hughes, T.P. (1987). *The evolution of large technological systems*. In T.P. Hughes, W.E. Bijker, T.P. Hughes, T.J. Pinch (Eds.), *The social construction of technological systems: new directions in the sociology and history of technology,* (pp. 51–82)MIT Press, Cambridge, MA

134. Ibitoye, F.I, Adenikinju, A., 2006. Future demand for electricity in Nigeria. *Applied Energy* 84 492–504.

135. Ibrahim, S.S. and Ibrahim, H. (2014). Budgetary Allocation Dynamics and Its Impact on Poverty Spread among the Geopolitical Zones of Nigeria. *American Journal of Economics*, 4(2): 124-129.

136. Ibuot, U. (2014, October 9). Nigeria: Why We Stopped Distribution of Pre-Paid Meters - Eko Disco. *Vanguard*. Retrieved from http://allafrica.com/stories/201410090384.html.

137. Ifowodo, O. "Paying the Police a livable minimum wage." Vanguard, May 15, 2013.

138. Ikeme, J., and Ebohon, O.J. (2004) Nigeria's electric power sector reform: what should form the key objectives? *Energy Policy. 33*, 1213-1221.

139. International Energy Agency/UN Dev. Program.. (IEA/UNDP/UN IDO). 2010.*Energy Poverty: How to make modern energy access universal?* Special early exerpt of the World Energy Outlook 2010 for the UN General Assembly on the Millineum

Development Goals. Retrieved from **http://www.worldenergyoutlook.org/docs/weo2010/weo2010_poverty.pdf**

140. Jellal, M, & Zenou, Y. (2005). Ethnic diversity, market structure and risk sharing in developing countries. CEPR Discussion Papers 5366.

141. Joseph, D. (2012). Nigerians Still Await Golden Era Of Uninterrupted Power Supply. Retrieved from http://naijalife.freehostia.com/mag/?p=4378

142. Joseph, I.O.O. (2014). Issues and challenges in the Privatized Power Sector in Nigeria. *Journal of Sustainable Development Studies, 6*(1), 161-174.

143. Kahn, A.E. (1989). *The Economics of Regulation: Principles and Institutions*. Cambridge, Mass: The MIT Press.

144. Kamalapur, G. D., Udaykumar, R. Y., & Karajgi, S. B. (2008). People's participation in rural electrification -A successful case. Paper presented at the Proceedings - *1st International Conference on Emerging Trends in Engineering and Technology, ICETET 2008*, 945-949. doi:10.1109/ICETET.2008.226

145. Kamp, L. M., & Vanheule, L. F. I. (2015). Review of the small wind turbine sector in kenya: Status and bottlenecks for growth. *Renewable and Sustainable Energy Reviews, 49*, 470-480. doi:10.1016/j.rser.2015.04.082

146. Karekezi, K. and Kithyoma, W., 2002. Renewable energy strategies for rural Africa: is a PV-led renewable energy strategy the right approach for providing modern energy to the rural poor of sub-Saharan Africa? *Energy Policy*, *30*1029-1045.

147. Karekezi, S. (2002). Poverty and energy in Africa – a brief review. *Energy Policy*, 30, 915–919.

148. Kasali, T.A., Sowunmi, F.A. (2013). The Effect of National Poverty Eradication Programme (NAPEP) Loan on Socio-Economic Development of Ogun State. *Asian Journal of Business Management,* 5(2): 208-212.

149. Kaserman, D.L., and Mayo, J.W. (1991). The measurement of vertical economics and the efficient structure of the electric utility industry. *The Journal of Industrial Economics*, 483-502.

150. Kates R. W. and Parris T. M. (2003). Long-term trends and a sustainability transition. *PNAS* 100(14), 8062-8067.

151. Kates, R.W., and Dasgupta, P. (2007). African poverty: A grand challenge for sustainability science. *PNAS*. 104 (43): pp 16747-16750.

152. Kates, R.W., Clark, W.C., Corell, R., Hall, J.M., Jaeger, C.C., Lowe, I., et al. (2001). Sustainability science. *Science* 292 (5517): 641–642.

153. Keating, M. F. (2006). *Global best practice(s) and electricity sector reform in Uganda*. Working Paper. Coventry: University of Warwick. Centre for the Study of Globalisation and Regionalisation. Working papers (University of Warwick. Centre for the Study of Globalisation and Regionalisation) (No.192)

154. Kebede B., Bekele A., Kedir E. (2002). Can the urban poor afford modern energy? The case of Ethiopia. *Energy Policy*, *30*(11–12), 1029-1045.

155. Kebede E., Kagochi J., and Jolly C. M. (2010) Energy consumption and economic development in Sub-Sahara Africa. *Energy Economics,* 32(3), 532-537.

156. Khapoya, V.B. *The African Experience: An Introduction*. San Francisco: Peachpit Press, 2012.

157. Khennas S. (2012). Understanding the political economy and key drivers of energy access in addressing national energy access priorities and policies: African Perspective. *Energy Policy*, 47(1), 21-26.

158. Kieffer, S.W., Barton, P., Palmer, A.R., Reitan, P.H., & Zen, E. 2003. Megascale events: Natural disasters and human behavior. *Geol. Soc. America* Abstracts with programs: 432.

159. Komiyama, H., Takeuchi, K. (2006). Sustainability science: building a new discipline. *Sustainability Science*, 1 (1): 1–6.

160. Krugman, H. and Goldemberg, J. (1983): 'The energy cost of satisfying basic human needs', *Technological Forecasting and Social Change*, 24, 45-60.

161. Le Billion, P. (2005). The resource curse. *Adelphi Papers* 45 (373), 11–27.

162. LeVan, A. C. (2014). Analytic authoritarianism and Nigeria. *Commonwealth and Comparative Politics*, 52(2), 212-231. doi:10.1080/14662043.2014.892722

163. Lior N. (2012). Sustainable energy development: The present (2011) situation and possible paths to the future. *Energy*, 43(1), 174-191.

164. Litosseliti, L. (2003). Using focus groups in research, Cornwall: Continuum.

165. Lloyd, P., Dick, A., Howells, M., Alfstad, T., 2002. A baseline study for Nkweletsheni. Energy Research Institute, University of Cape Town.

166. Lugard, F. (1922). The dual mandate in British tropical Africa. London: W. Blackwood and Sons.

167. Macartan, H et al. (2007). *Escaping the Resource Curse*. New York: Columbia University Press.

168. Maclaren V.W. (1996). Urban Sustainability Reporting. *Journal of the American Planning Association*, 62(2):184-202.

169. Mahoney, J. (2003). Long-run development and the legacy of colonialism in Spanish America. *American Journal of Sociology*, 109(1), 50–106.

170. Makan, A. (2013, October 10). Nigerian natural gas waiting to be tapped. *Financial Times*. Retrieved from http://www.ft.com/intl/cms/s/0/656c3abe-2440-11e3-a8f7-00144feab7de.html#axzz3QntVOE75

171. Mamdani, M. (1996). *Citizen and subject*. Princeton, NJ: Princeton University Press.

172. Marland, G., T.A. Boden, and R. J. Andres, 2005, Global, regional, and national CO_2 emmissions. Trends: A Compendium of Data on Global Change, Carbon Dioxide Information Analysis Center, Oak Ridge National Laboratory, U.S. Department of Energy, Oak Ridge, Tennessee.

173. Martchamadol J, Kumar S. (2013). An aggregated energy security performance indicator. *Applied Energy*, 10, 653–70.

174. Meagher,K., and Mohammed-Bello, Y. United Nations Research Institute for Social Development. The Social Effects of Globalization. Passing the Buck: Structural Adjustment and the Nigerian Urban Informal Sector. Geneva: UN 1996.

175. Mehlum, H., Moene, K., and Torvik. R. (2006). Institutions and the resource curse. *The Economic Journal*, 116:1–20.

176. Mihelcic, J.R, et al., 2003, Sustainability Science and Engineering: The Emergence of a New Metadiscipline. *Environmental Science & Technology*, 37(23): 5314-5324.

177. Mimmi, L.M., 2014. From informal to authorized electricity service in urban slums: Findings from a household level survey in Mumbai. *Energy for Sustainable Development*, 21, 66–80.

178. Mishra, T. (2015). *Characterizing Energy Poverty: Implications for Energy Access Policies* In B. Sudhakara Reddy, S. Ulgiati (Eds.), *Energy Security and Development: The Global Context and Indian Perspectives* (pp 321 – 329). India: Springer.

179. Modi V, McDade S, Lallement D, Saghir J. (2005). Energy services for the millennium development goal. Millennium Project: UNDP. The World Bank and Energy Sector Management Assistance Program (ESMAP), pp. 2e4.

180. Mohammed, Y.S. et al. (2013). An overview of agricultural biomass for decentralized rural energy in Ghana. *Renewable and Sustainable Energy Reviews*, 20, 15-25.

181. Morse, Janice, M. (2000). Determining sample size. *Qualitative Health Research*, *10*(1), 3-5.

182. Moseley W. G. (2001). African evidence on the relation of poverty, time preference and the environment. *Ecological Economics*, 38(3), 317-326.

183. Mukasa, A.D., Mutambatsere, E., Arvanitis, Y., and Triki, T., 2015. Wind Energy in Sub-Saharan Africa: Financial and political causes for Africa's under-development of wind energy. *Energy Research and Social Science*. 5, .

184. Myrskyla, M., Kohler, H., Billari, F.C. (2009). Advances in development reverse fertility declines. *Nature*, 460, 741-743.

185. Nau, D., 1995. Mixing methodologies: can bimodal research be a viable post-positivist tool?, *The Qualitative Report*, online serial, www.nova.edu/ssss/QR/QR2-3/nau.html, 2(3).

186. NEPAD. (2001). The New Partnership for Africa's Development. New Partnership for Africa's Development (NEPAD), Pretoria, South Africa.

187. Ngala, G.M., Alkali, B., Aji, M.A., 2007. Viability of wind energy as a power generation source in Maiduguri, Borno state, Nigeria. *Renewable Energy*, 32(13), 2242-2246.

188. Nhete, T.D. (2007). Electricity sector reform in Mozambique: a projection into the poverty and social impacts. *Journal of Cleaner Production*, 15: 190-202.

189. Nigerian Electricity Regulatory Commission (NERC). 2013. Tariff, charges, and market rules. Retrieved from http://www.nercng.org/index.php/document-library/Tariff-Charges--and--Market-Rules/

190. Nigerian National Energy Policy. Federal Republic of Nigeria. 2003.

191. Nigerian National Petroleum Corporation (NNPC), 2014. Oil Production. Retrieved from http://www.nnpcgroup.com/NNPCBusiness/UpstreamVentures/OilProduction.aspx

192. Nigerian Research Institutes. Nigeria Master Web. Retrieved from http://nigeriamasterweb.com/ResearchInsts.html on 04/05/2013.

193. NNPC. 2015. The Nigerian National Petroleum Corporation Group.

194. Normann, H.E. (2015). The role of politics in sustainable transitions: The rise and decline of offshore wind in Norway. *Environmental Innovation and Societal Transitions*, 15, 180–193.

195. Nussbaumer, M. C. and Sen, A. (1993). The Quality of Life, Oxford: Clarendon Press.

196. Nussbaumer, P., Bazilian, M., & Modi, V. (2012). Measuring energy poverty: Focusing on what matters. *Renewable and Sustainable Energy Reviews, 16*(1), 231-243. doi:10.1016/j.rser.2011.07.150

197. Nwokpoku, J. (2014, October 14). Nigeria needs 6.5m pre-paid meters in five years — Onyema. *Vanguard Nigeria*. Retrieved from:

http://www.vanguardngr.com/2014/10/nigeria-needs-6-5m-pre-paid-meters-five-years-onyema/

198. Oakerson, R. J. and Parks, R. B. (2011). The Study of Local Public Economies: Multi-organizational, Multi-level Institutional Analysis and Development. *Policy Studies Journal,* 39(1), 147–167.

199. Obi, C. (2013). Taking back our democracy? the trials and travails of nigerian elections since 1999 doi:10.4324/9780203718742

200. Obi, S.N.C. (1963). *The Ibo law of property*. London: Butterworths.

201. O'Dell, K., Peters, S., & Wharton, K. (2014). Women, energy, and economic empowerment: Applying a gender lens to amplify the impact of energy. Paper presented at the *World Energy Engineering Congress, WEEC 2014,* 1200-1211.

202. Ogbogbo, C.B.N. (2004) "The Beginning of the Oil Industry in Nigeria1906-1956" *Quill pen 4*, 1-9

203. Ogumwike, F.O. et al. (2014). Household Energy Use and Determinants: Evidence from Nigeria. *International Journal of Energy Economics and Policy*, 4(2): 248-262.

204. Oirere, S. Lenders and leading developer focus on Nigerian market. PV Magazine 8 August 2014: web.

205. Okoro, O.I, & Chikuni, E. (2007). Power sector reforms in Nigeria: opportunities and challenges. *Journal of Energy in Southern Africa*, 18(3): 52-57.

206. Olukoju, A. (n.d.) *Infrastructure development and urban facilities in Lagos, 1861-2000.* Retrieved from http://books.openedition.org/ifra/829

207. Omotosho, M. (2014). Managing religious conflicts in nigeria: The inter-religious mediation peace strategy. *Africa Development, 39*(2), 133-152.

208. Oni, A. (2012, August 9). The PIB, Gas and the Nigerian Electricity Supply Industry. *Business Day.* Retrieved from http://businessdayonline.com/NG/index.php/law/cover/42510-the-pib-gas-and-the-nigerian-electricity-supply-industry.

209. Onyeji et al. (2012). Contextualizing electricity access in sub-Saharan Africa. *Energy for Sustainable Development* 16: 520–527.

210. Oparaocha, S., & Dutta, S. (2011). Gender and energy for sustainable development. *Current Opinion in Environmental Sustainability, 3*(4), 265-271. doi:10.1016/j.cosust.2011.07.003

211. Oseni, M.O. (2012). Households' access to electricity and energy consumption pattern in Nigeria. *Renewable and Sustainable Energy Reviews, 16*, 990–995

212. Ostrom, E. (2007). A diagnostic approach for going beyond panaceas. *Proceedings of the National Academy of Science*. 104, 15181-15187.

213. Otto, G. (2008). *Urbanisation in Nigeria: Implications for Socio-Economic Development*. Owerri: JORIND.

214. Oyedepo S. O. (2012). On energy for sustainable development in Nigeria. *Renewable and Sustainable Energy Reviews*, 16(5), 2583-2598.

215. Oyedepo, S. O. (2012). Energy and sustainable development in Nigeria: the way forward. *Energy, Sustainability and Society*, **2**:15.

216. Pachauri, S., & Spreng,D. (2011). Measuring and monitoring energy poverty. *Energy Policy*. 39, 7497-7504.

217. Pachauri, S., Spreng, D., 2004. Energy use and energy access in relation to poverty. *Econ and Pol Wkly* 39 (3).

218. Padr´o i Miquel, G. (2007). The Control of Politicians in Divided Societies: The Politics of Fear. *The Review of Economic Studies* 74(4): 1259–1274.

219. Pandey R. (2001). Energy policy modelling: agenda for developing countries. *Energy Policy,* 30(2), 97-106.

220. Parag, Y. and Janda, K.B. (2010). More than filler: Middle actors and socio-technical change in the energy system from the "middle-out". *Energy Research & Social Science,* 3, 102–112.

221. Parajuli, R. (2011). Access to energy in Mid/Far west region-Nepal from the perspective of energy poverty. *Renewable Energy* 36, 2299-2304.

222. Pegg, S. (2010). Is there a Dutch disease in Botswana. *Resource Policy 35*, 14–19.

223. Pereira, M. G., Freitasa, M. A. V., and Da Silvaa, N. F., 2011. The challenge of energy poverty: Brazilian case study. *Energy Policy*, 39(1), 167–175.

224. Persson, T. et al. (1997). Separation of Powers and Accountability. *Quarterly Journal of Economics*, 112: 1163-1202.

225. Peters J., Harsdorff M., Ziegler F. (2009). Rural electrification: Accelerating impacts with complementary services. *Energy for Sustainable Development*, 13(1), 38-42.

226. Pieterse, E. (2010). Filling the void: Towards an Agenda for Action on African Urbanisation. In: African Centre for Cities Urbanisation Imperatives for Africa: Transcending Policy Inertia . Cape Town: University of Cape Town. pp. 7–45.

227. Port From Kerosene, Firewood To Gas, Fashola Urges Lagosians. *Channels TV*. (2013, June 13) Retrieved from http://www.channelstv.com/home/2013/06/11/port-from-kerosenefirewood-to-gas-fashola-urges-lagosians/

228. Potts, D. 2012. Challenging the Myths of Urban Dynamics in Sub-Saharan Africa: The Evidence from Nigeria. *World Development* Vol. 40, No. 7, pp. 1382–1393

229. Poverty headcount ratio at $1.25 a day (PPP) (% of population). Retrieved from http://data.worldbank.org/topic/poverty

230. Practical Action. (2008). Energy poverty: Estimating the level of energy poverty in Sri Lanka.

231. Prasad, G., 2002. Personal communication. Energy and Development Research Centre, University of Cape Town.

232. Quah, J. S. T. (2010). *Chapter 11: Public administration singapore-style* doi:10.1108/S0732-1317(2010)0000019016

233. Reitan, P. (2005). Sustainability science – and what's needed beyond science. *Sustainability: Science, Practice, & Policy* 1(1):77-80.

234. Reno, W. *Corruption and state politics in Sierra Leone*. New York: Cambridge University Press. 1995.

235. Rip, A., Kemp, R. (1998). Technological change. In: Rayner, S., Malone, E.L. (Eds), *Human Choice and Climate Change*, Vol.2. Battelle Press, Columbus, OH, pp. 327–399.

236. Rockstrom J, et al. (2009). A safe operating space for humanity. *Nature*, 461, 472-475.

237. Rosenbloom, D., and Meadowcroft, J. (2014). The journey towards decarbonization: Exploring socio-technical transitions in the electricity sector in the province of Ontario (1885–2013) and potential low-carbon pathways. *Energy Policy,* 65, 670–679.

238. Ross, M.L. (1999). The political economy of the resource curse. *World Politics* 51 (2), 297–322.

239. Rotmans, J., Kemp, R., van Asselt, M. (2001). More Evolution than Revolution; Transition Management in Public Policy. *Foresight*, 03(1), 15-31 .

240. Sadorsky, P. 2013. Do urbanization and industrialization affect energy intensity in developing countries? *Energy Economics,* 37, 52–59.

241. Sagar, A.D. (2005) Alleviating energy poverty for the world's poor. *Energy Policy*, 33(11), 1367-1372.

242. Saldana J (2009) The coding manual for qualitative researchers. SAGE, Los Angeles.

243. Sambo A. S., Garba B., Zarma I. H. and Gaji M. M. (2009). Electricity Generation and the Present Challenges in the Nigerian Power Sector. *World Energy Council.*

244. Sandelowski, M., 1995. Focus on qualitative methods: sample size in qualitative research. *Research in Nursing and Health*, 18, 179-183.

245. Schäfer, M., Kebir, N., and Neumann, k. (2011). Research needs for meeting the challenge of decentralized energy supply in developing countries. *Energy for Sustainable Development*, 15, 324–329.

246. Schlör H, Fischer W, & Hake J. (2013). Methods of measuring sustainable development of the German energy sector. *Applied Energy*, 101, 172–81.

247. Schoch, T et al. (2012). Social inequality and the biological standard of living: An anthropometric analysis of Swiss conscription data, 1875–1950. *Economics and Human Biology*, 10: 154–173.

248. Schuitmaker, T.J. (2012). Identifying and unravelling persistent problem. *Technological Forecasting and Social Change* 79, 1021–1031.

249. Sgouridis, S. et al. (2013). A sustainable energy transition strategy for the United Arab Emirates: Evaluation of options using an Integrated Energy Model. *Energy Strategy Reviews*, 2, 8-18.

250. Shleifer, Andrei, and Robert Vishny. (1993). Corruption. *Quarterly Journal of Economics*, 108: 599-617.

251. Siddayao C. M. (1998). Energy policy issues in developing countries Lessons from ASEAN's experience. *Energy Policy,* 16(6), 608-620.

252. Skjærseth J. B., Tangen K., Swanson P., Christiansen A. C., Moe A., and Lunde L. (2004). Limits to Corporate Social Responsibility: A comparative study of four major oil companies. Fridtjof Nansen Institute, Norway.

253. Smith A. (2007). Emerging in between: the multi-level governance of renewable energy in the English regions. *Energy Policy*, 35(12):6266–80.

254. Sokoloff, K., & Engerman, S. (2000). Institutions, factor endowments, and paths of development in the New World. *Journal of Economic Perspectives*, 14(3), 217–232.

255. Sokona Y., Mulugetta Y., and Gujba H. (2012). Widening energy access in Africa: Towards energy transition. *Energy Policy,* 47(1), 3-10.

256. Sonibare, J. A., Adeniran, J. A., Fakinle, B. S., Latinwo, I. O., Jimoda, L. A., & Olu-Arotiowa, O. A. (2014). Ambient noise from off-grid diesel engines electric power generators in an urban environment. *Management of Environmental Quality, 25*(2), 186-199. doi:10.1108/MEQ-12-2012-0078

257. Sonibare, J.A., and Akeredolu F.A. (2006). Natural gas domestic market development for total elimination of routine flares in Nigeria's upstream petroleum operations. *Energy Policy*. Vol. 34, pp. 743-753.

258. Soriwei, F. "NLC faults move to change minimum wage law." Punch, July 1, 2013.

259. Sovacool, B. K. (2013). Confronting energy poverty behind the bamboo curtain: A review of challenges and solutions for Myanmar (Burma). *Energy for Sustainable Development* 17: 305–314.

260. Sovacool, B.K. (2014). What are we doing here? Analyzing fifteen years of energy scholarship and proposing a social science research agenda. *Energy Res Soc Sci*, 1 pp. 1–29

261. Sovacool, B.K. et al. (2011). Halting hydro: A review of the socio-technical barriers to hydroelectric power plants in Nepal. *Energy*, 36(5): 3468–3476.

262. Sovacool, B.K. (2012). The political economy of energy poverty: A review of key challenges. *Energy for Sustainable Development* 16(3), 272-282.

263. Sowunmi F. A., Akinyosoye V. O., Okoruwa V.O., Omonona B. T., 2012. The Landscape of Poverty in Nigeria: A Spatial Analysis Using Senatorial Districts- level Data. *Am Jnl of Econ*, 2(5), 61-74.

264. Spencer H. (1897). *First Principles*. New York: Appleton

265. Steinbuks, J. & Foster, V. (2010). When do firms generate? Evidence on in-house electricity supply in Africa. *Energy Economics*, 32, 505–514.

266. Stephens, J.C., Jiusto, S. (2010). Assessing innovation in emerging energy technologies: socio-technical dynamics of carbon capture and storage (CCS) and enhanced geothermal systems (EGS) in the USA. *Energy Policy* 38, 2020–2031

267. Stevens, P., Dietsche, E. (2008). Resource curse: an analysis of causes, experiences and possible ways forward. *Energy Policy*, 36: 56–65.

268. Strauss, A., & Corbin, J. (1998). *Basics of qualitative research: Techniques and procedures for developing grounded theory* (2nd ed.). Thousand Oaks, CA: Sage.

269. Sudhakara Reddy, B., & Nathan, H. S. K. (2013). Energy in the development strategy of indian households - the missing half. *Renewable and Sustainable Energy Reviews, 18*, 203-210. doi:10.1016/j.rser.2012.10.023

270. Sutherland, L., Peter, S., & Zagata, L. (2015). Conceptualising multi-regime interactions: The role of the agriculture sector in renewable energy transitions. *Research Policy, 44*(8), 1543-1554. doi:10.1016/j.respol.2015.05.013

271. Swart RJ, Raskin P, Robinson J. (2004). The problem of the future—Sustainability science and scenario analysis. *Global Environ Change, 14,* 137-146.

272. Hughes T.P. (1983). *Network of power: electrification in Western society, 1880–1930.* Johns Hopkins University Press, Baltimore

273. The White House, Office of the Press Secretary. (2013). Making Energy More Accessible in Africa: The Power Africa Off-Grid Energy Challenge [Press release]. Retrieved from https://www.whitehouse.gov/blog/2013/09/24/making-energy-more-accessible-africa-power-africa-grid-energy-challenge

274. The White House, Office of the Press Secretary. (2014). FACT SHEET: Powering Africa: Increasing Access to Power in Sub-Saharan Africa [Press release]. Retrieved from http://www.whitehouse.gov/the-press-office/2014/08/05/fact-sheet-powering-africa-increasing-access-power-sub-saharan-africa

275. Tinashe D. N. (2007). Electricity sector reform in Mozambique: a projection into the poverty and social impacts. *Journal of Cleaner Production*, 15(2), 190-202.

276. Todaro, M. (2000). *Economic Development*. Essex: Pearson Education Limited.

277. Toman, M., Lemelkova, B., 2003. Energy and economic development: an assessment of the state of knowledge. *The Energy Journal*, *24* (4)

278. Ulsrud, K., Winther, T., Palit, D., & Rohracher, H. (2015). Village-level solar power in Africa: Accelerating access to electricity services through a socio-technical design in Kenya. *Energy Research and Social Science, 5*, 34-44. doi:10.1016/j.erss.2014.12.009

279. UNDP. (2010). Energy for a Sustainable Future. The Secretary-General's Advisory Group On Energy And Climate Change (AGECC) Summary Report and Recommendations, Washington, DC.

280. UNDP. (2007). Access to energy and human development. Human Development Report 2007/2008, United Nations Development Program Human Development Report Office Occasional Paper.

281. UNDP/WB. (2003). Household energy use in developing countries. A multi country study. Energy Sector Management Assistance Program (ESMAP) of the UNDP and World Bank. Washington, DC.

282. United Nations Department of Economic and Social Affairs Population Division. World urbanization prospects: the 2011revision. New York, NY: UN. 2012

283. Unruh, G.C. (2000). Understanding carbon lock-in. *Energy Policy*, 28:817–30.

284. Urban, F., Benders, R.M.J., Moll, H.C. (2007). Modelling energy systems for developing countries. *Energy Policy*, *35*, 3473-3482.

285. Van der Ploeg, F., & Poelhekke, S. (2009). Volatility and the natural resource curse. *Oxford economic papers*, gpp027.

286. Van der Schoor, Scholtens, B. (2015). Power to the people: Local community initiatives and the transition to sustainable energy. *Renewable and Sustainable Energy Reviews*, 43, 666–675.

287. Van der Vleuten, E., & Raven, R. (2006). Lock-in and change: Distributed generation in denmark in a long-term perspective. *Energy Policy, 34*(18), 3739-3748. doi:10.1016/j.enpol.2005.08.016

288. Verbong, G., and Geels, F. (2007). The ongoing energy transition: Lessons from a socio-technical, multi-level analysis of the Dutch electricity system (1960–2004). *Energy Policy,* 35, 1025–1037.

289. Vermaak C,, Kohler M., and Rhodes B., 2009. Developing Energy-based Poverty Indicators for South Africa. *Journal of Interdisciplinary Economics*, 21,163-195.

290. Vithayasrichareon P, MacGill IF, Nakawiro T. (2012). Assessing the sustainability challenges for electricity industries in ASEAN newly industrializing countries. *Renewable Sustainable Energy Reviews*, 16, 2217–33.

291. Watts, M. (2010). *Curse of the Black Gold: 50 Years of Oil in the Niger Delta*. New York: Power House Books.

292. WEC, 1999. The challenge of rural energy poverty in developing countries. In: (Eds.), World Energy Council and Food and Agricultural Organization of the United Nations, London.

293. Weller, S. C., and Romney, A. K.,(Eds). (1988). *Systematic data collection*. Sage, Thousand Oakes, California, USA.

294. Wiek, A., and Childers, D. L. (2010). Crafting science-based solutions for sustainability problems in complex social- ecological systems. *PNAS*, (March).

295. Wiek, A., Ness, B., Brand, F.S., Schweizer-Ries, P., & Farioli, F. (2012). From complex systems analysis to transformational change: A comparative appraisal of sustainability science projects. *Sustainability Science, 7(1),* 5-24

296. Wilkinson, R., Cary, J. (2002). Sustainability as an evolutionary process. *International Journal of Sustainable Development*, 5, 381–391.

297. Williams, N. J., Jaramillo, P., Taneja, J., & Ustun, T. S. (2015). Enabling private sector investment in microgrid-based rural electrification in developing countries: A review. *Renewable and Sustainable Energy Reviews, 52,* 1268-1281. doi:10.1016/j.rser.2015.07.153

298. Wolde-Rufael, Y. (2005). Energy demand and economic growth: The African experience. *Journal of Policy Modeling*, 27, 891–903

299. Yeager, K., 2001. Electricity development for a sustainable world: bridging the digital divide. *World Energy Council 18th Congress*-Buenos Aires.

300. Young, C. (1994). *The African colonial state in comparative perspective*. New Haven, CT: Yale University Press.

301. Yuan, J., Xu, Y., Hu, Z., Yu, Z., Liu, J., Hu, Z., & Xu, M. (2012). Managing electric power system transition in china. *Renewable and Sustainable Energy Reviews, 16*(8), 5660-5677. doi:10.1016/j.rser.2012.05.046

APPENDIX

APPENDIX A

HOUSEHOLD SURVEYS

HOUSEHOLD SURVEYS

ASU SCHOOL of SUSTAINABILITY
ARIZONA STATE UNIVERSITY

I am inviting your participation to answer a short survey concerning energy resources as well as human asset capital in the city of Ibadan. The information you give will be used without revealing your actual name. We will be referencing you by an assigned participant number. Your responses will be anonymous. The results of this study may be used in reports, presentations, or publications but your name will not be used. If you have any questions about the survey, feel free to contact me at nonso.emordi@asu.edu.
Please restrict all answers in the survey to your current living situation.

Part 1. Demographic Data

1. Age (*please circle one*):

   18-25yrs   26-35yrs   36-45yrs   46-55yrs   55-65yrs   66yrs or older

2. Sex (*please circle one*): *M   F*

3. Occupation (*please check all that apply*):

   ❑ **Student (Undergraduate)**

   ❑ **Student (Postgraduate)** ❑ **Professional (e.g. Doctor, Laywer, Pharmacist, Professor, etc)**

   ❑ **Civil Servant**

   ❑ **Contract Worker (e.g. cleaner, grounds keeper, etc)**

   ❑ **Petty Trader/ Self Employed (e.g. market woman, recharge card sales person, etc)**

   ❑ **Entrepreneur (e.g. caterer, mechanic, etc)**

4. What is the average monthly household income? (*please circle one*):

   ₦2000 – ₦5000   ₦5001- ₦10,000   ₦10,001- ₦15,000

   ₦15,001- ₦25,000   ₦25,001- ₦40,000   ₦40,001- ₦80,000

   ₦80,001- ₦100,000   ₦100,001- ₦150,000   >₦150,000

5. Have you lived in Oyo state for the past 5 years? (*please circle one*)   *Y   N*

6. Have you lived in the city of Ibadan for the past 5 years? (*please circle one*)   *Y   N*

7. What is your best estimate of your average household size? (*please circle one*)

   2 – 4 people   5-7 people   8 -10 people   more than 10 people

School of Sustainability
Box 875502, Tempe, Arizona 85287-5502
Phone: (480) 965- Fax: (480)965-8087

8. What is the highest level of education of parents? *(please circle one)*

Primary School Secondary School Diploma/Technical School University Postgraduate Degree

Part 2. Energy Data

9. What household electrical appliances do you have in your home (*please circle all that apply*):

Refrigerator Fan Iron Airconditioner Microwave Oven

10. What household entertainment/education appliances do you have in your home (*please circle all that apply*):

Television Radio/sound system DVD player Video game system

11. What telecommunication means do you have in your home? (*please circle all that apply*):

mobile phone smart phone (e.g. blackberry, HTC, etc) landline (NITEL) internet

12. Do you have a generator? (*please circle one*) *Y* *N*

13. Do you have an inverter system ? (*please circle one*) *Y* *N*

14. On average, how many hours of electricity do you get daily? ______________________

15. Which of these types of stoves do you have in your home? (*please circle all that apply*):

Kerosine stove Gas cooker/burner Electric cooker

16. Do you use firewood in cooking in your household? *(please circle one)* *Y* *N*

    16.1 How do you obtain your firewood? *(please circle one)* *it is collected* *it is purchased*

    16.2 If you do, who collects it? *(please circle one)* *Children* *Mother* *Father* *Self*

    16.3 How long does it take to collect biofuels? ____________ *Hours*

    16.4 Why do you use firewood? *(please circle all that apply)*

    It is cheaper
    It makes food taste better
    Other reason ________________

17. Do you use gas in cooking? *(please circle one)* *Y* *N*

School of Sustainability
Box 875502, Tempe, Arizona 85287-5502
Phone: (480) 965- Fax: (480)965-8087

17.1 If you don't, what is the reason? *(please circle all that apply)*

It is expensive
I am not used to it
Other reason ___________________

Part 3. Capital Stock/Flow Data

18. How much of your monthly salary is spent on cooking fuel? ___________________

19. How much of your monthly salary is spent on fuel for generator?________________

20. How much of your monthly salary is spent on your NEPA/PHCN bill?_____________

21. Do you have a savings account? *(please circle one)* *Y* *N*

Part 4. Human Assets Data

22. How long does it take to get to the market from your home?_____________________

23. How long does it take to get to the hospital from your home?____________________

24. How long does it take to get to school from your home ? _______________________

25. Do you have a toilet and bathroom inside your apartment? *(please circle one)* *Y* *N*

26. How many toilets are in the house?__________________

27. How do you get drinking water in the house? *(please circle all that apply)*

I buy pure water/bottled water
I boil tap water
I disinfect tap/well water

28. How do you get water to use in the house? *(please circle one)*

With a water pump from the well in my compound
Buy from a water seller
Rainwater
I fetch from a public tap
Other ____

Thank you very much for participating in this survey. Good luck on your final exams!

School of Sustainability
Box 875502, Tempe, Arizona 85287-5502
Phone: (480) 965- Fax: (480)965-8087

APPENDIX B

CODING METHODOLOGY

CODING METHODOLOGY

Data Analysis

Using principles of grounded theory, the author and an academic colleague independently coded the data to identify recurrent themes, selecting participant comments that served as examples of each theme. Both researchers met to assess the concurrence of themes with supporting comments, new themes that might have arisen, and completeness of codes. Also, themes that did not have a frequency greater than two were discarded. Coding disparities were discussed until consensus was reached with documented transcripts checked to context and accuracy.

Results

Participant Demographics

There were three groups of participants – lay persons that included petty traders, low-skilled laborers, as well as self-employed business men and women; graduate students; and faculty.

Group 1: Lay persons

There were 15 participants comprising 4 men and 11 women. The mean age was 43±3.8 years (range = 26 to 77 years).

Group 2: Graduate students

There were 15 participants comprising 9 men and 6 women. The mean age was 28.3±1 years (range = 21 to 36 years.

Group 3: Faculty

There were 15 participants, 3 females 12 males. Inquiring of age in this group was deemed to be improper.

All were found to experience energy poverty in the form of challenges in terms of either financial or human capital.