Tunyi Gejung Ashigho

ENERGY POVERTY AND TRENDS IN SUB- SAHARAN AFRICA

Dissertation in energy system and policy
Masters of Science in Energy for sustainability

July 2016

· U C ·

UNIVERSIDADE DE COIMBRA

Cover image source:

https://joinmosaic.com/blog/solar-energy-developing-world-part-1-problem/

(Photo courtesy From Concentrate)

Accessed online on 18 June, 2016

UNIVERSIDADE DE COIMBRA

ENERGIA PARA A SUSTENTABILIDADE
ENERGY FOR SUSTAINABILITY

Tunyi Gejung Ashigho

Energy Poverty and trends in Sub-Saharan Africa

Master Dissertation in Energy for Sustainability, developed on the specialization branch in Energy Systems and Policy, presented to the Faculty of Science and Technology of the University of Coimbra, as part of the requirements for the award of the Master Degree.

Supervisor: Professor Patrícia Pereira da Silva Ph.D

Coimbra, 2016

ACKNOWLEDGEMENT

The completion of this thesis would not have been possible without the contribution of many people I cannot mention here. I am entirely grateful to my supervisor, Professor Patricia Pereira da Silva, Ph.D. Faculty Member of the Faculty of Economics of the University of Coimbra and of the Energy for Sustainability Initiative of the University of Coimbra, Portugal for her continuous support, encouragement, discussions and feedbacks making this process a success. Also, I am grateful to Professor Pedro Cerqueira of the University of Coimbra, Portugal and Dr. Patrick Nussbaumer of UNIDO for their contributions and advice towards achieving this research.

My acknowledgement will be incomplete without making mention of my Family and friends for their unwavering love and support throughout my program especially my mother Tunyi Beatrice and my elder brother Dr Tunyi Abongeh Akumbom of the Liverpool Hope University, United Kingdom, for his mentorship, financial and moral support. Finally and most importantly to my kids, Larry Mbibong and Mbwameh Latisha-Kaelle for the enormous sacrifice and maturity they have shown allowing me to go through this program.

ABSTRACT

Energy poverty is a phenomenon which hinders growth and development today in both developed and developing countries. This concept is not universal and has been defined by several authors in different context and looked upon from different perspectives. In developed countries, energy poverty has been frequently described using the terms fuel poverty and energy poverty interchangeably. In the case of developing countries, energy poverty occurs when households are unable to afford proper energy services to cover their daily needs which negatively impacts them socially, environmentally and economically. This can be narrowed down to the high dependence on biomass for cooking and the lack of adequate access to electricity for lighting.

Statistics derived from the International Energy Agency (IEA) demonstrates that by 2013, 1.2 billion people did not have access to electricity and about 2.7 billion people worldwide used biomass for cooking. Projections for 2030 show that this situation is not going to significantly change if much is not being done to eradicate the problem. This work is aimed at analyzing energy poverty in 30 Sub Saharan African Countries and also establishing the trends in energy poverty in these selected countries. The drivers behind energy poverty are examined as well in order to bring to light the pillars on which this problem is built on and must be tackled if any change is desired.

Using the MEPI methodology and specific indicators related to the study area, it is evident that energy poverty still occurs in all these countries. The trends illustrates a slide reduction in multidimensional energy poverty index (MEPI) in all countries with the exception of Angola and Madagascar, when compared to the results of 2011 analysis presented in Nussbaumer, Bazilian, & Modi., (2012).

Key words:

Energy poverty, Multidimensional energy poverty index (MEPI), Electricity, Biomass, Sub Saharan Africa.

RESUMO

A pobreza energética é um fenómeno que actualmente impede o crescimento e desenvolvimento tanto em países desenvolvidos com em países em desenvolvimento. A sua definição não é única nem consensual e o seu conceito difere entre os autores, que partem de contextos e perspectivas diferentes para a alcançar. Nos países desenvolvidos, a pobreza energética tem sido frequentemente descrita usando, indiferenciadamente, os termos de pobreza de combustível e de pobreza de energia. No caso dos países em desenvolvimento, a pobreza energética ocorre quando as famílias são incapazes de pagar serviços de energia adequados para cobrir suas necessidades diária, o que impacta estes países de forma negativa, a nível social, ambiental e económico. Neste caso, o conceito por vezes é reduzido à questão da forte dependência de biomassa para cozinhar e à falta de acesso adequado a electricidade para iluminação.
As estatísticas apresentadas pela da Agência Internacional de Energia (AIE) evidenciam que, até 2013 e em todo o mundo, 1,2 biliões de pessoas não têm acesso a electricidade e que cerca de 2,7 mil milhões de pessoas utilizam biomassa para cozinhar. As projecções para 2030 apontam para que esta situação não mude significativamente, se nada for entretanto feito para erradicar o problema. Neste contexto, este trabalho tem como objectivo analisar a pobreza energética em 30 países da África subsariana e também percepcionar as tendências de pobreza energética nesses mesmos países. São estudados os principais factores influenciadores de pobreza energética de modo a poder sugerir pistas para mitigar o problema. Utilizando a metodologia *multidimensional energy poverty index* (MEPI) e indicadores específicos com ela relacionados, torna-se evidente que a pobreza energética ainda ocorre em todos esses países. Todavia, constatamos uma ligeira redução deste índice em todos os países estudados, à excepção de Angola e Madagáscar, quando comparamos com os resultados da análise similar, datada de 2011, apresentados em Nussbaumer, Bazilian, e Modi. (2012).

Palavras-chave: Pobreza de energia, *multidimensional energy poverty index* (MEPI), Eletricidade, Biomassa, Subalterno Saharan a África.

Table of Contents

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS AND ACRONYMS

ABBREVIATION & ACRONYMS	MEANINGS
MEPI	Multidimensional Energy Poverty Index
UN	United Nations
USAID	United States Agency for International Development
DHS	Demographic health survey
SDG	Sustainable Development Goals
MDG	Millennium Development Goals
UNIDO	United Nations Industrial Development Organisation
IEA	International energy association
WEO	World Economic Outlook
NGO	Non-governmental organisation
PV	Photovoltaic
LPG	Liquid petroleum gas
KWh	Kilowatt hour
GWh	Gigawatt hour
A	Intensity of energy poverty
H	Headcount ratio
OECD	Organization For Economic Co-Operation And Development
LDC	Less developed countries
NSSO	National sample survey organisation
GHG	Greenhouse gas

CHAPTER ONE: INTRODUCTION

Energy is vital for our day to day lives. The United Nations, IEA, World Bank and many other international organizations have joined in the fight to tackle climate change in the world but it is important to note that we cannot address this global challenge without working on our energy future. Access to energy services brings about many solutions but limited energy access is an impeding problem termed energy poverty which affects many households both in developed and developing countries. The concept of energy poverty is not universal and has been defined by several authors in different contexts (expatiated in chapter 2). With the enthusiasm of governments and international organizations to increase the awareness of the energy poverty problem today, it has become very critical to analyze energy poverty in any country. For this to be successful, the starting point involves defining energy poverty for these countries. In developed countries, energy poverty has been frequently described using the terms fuel poverty and energy poverty interchangeably. In the case of developing countries, energy poverty occurs when households are unable to afford proper energy services to satisfy their daily needs. This has been narrowed down to the high dependence on biomass for cooking and the lack of adequate access to electricity for lighting.

The main objective of this study is to analyze the level of energy poverty in selected Sub-Saharan African countries for which data is available, given that data is an indispensable part of this project.

The specific objectives of this dissertation are-

a) To evaluate the drivers behind energy poverty
b) To measure the multidimensional energy poverty index of selected sub-Saharan African countries namely Angola, Benin, Burkina Faso, Burundi, Cameroon, Comoros, Congo Brazzaville, Congo Democratic Republic, Cote D'Ivoire, Ethiopia, Gabon, Gambia, Ghana, Guinea, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leonne, Tanzania, Togo, Zambia, Zimbabwe and

c) To examine the trends in energy poverty in these countries

In order to achieve these objectives, understanding energy poverty from different perspectives is essential first by looking at the problem on a global scale to set a foundation on which to comprehend the different dimensions at which energy poverty occurs and how it can be tackled. This has been done as part of the effort to identify the major indicators associated with energy poverty in less developed countries specifically in Sub-Saharan Africa.

The availability, accessibility and affordability of modern energy services drives growth and development in any society, given that energy is fundamental to our daily lives in providing basic services such as lighting, cooking, heating/cooling, education and entertainment, transportation and mechanical power. The lack of modern energy services is detrimental and its consequences are far reaching and affect any society in different magnitudes of sustainable development, namely, socially, economically and environmentally.

The purpose of this research is to measure energy poverty using the Multidimensional energy poverty index (MEPI) proposed by Nussbaumer et al., (2012). It analysis 30 Sub-Saharan African countries for which reliable data is available, using the most recent Demographic and Health Survey- MEASURE DHS data[1]. This source of data contains a recode data file in a standardized format with the same structure across countries participating in each DHS phase. This standardization is meant to allow comparison across surveys. The recode structure utilized in this survey is that defined for households for the sixth (VI) and seventh (VII) rounds of DHS surveys[2]. Today energy poverty is still a problem faced in Sub-Saharan Africa and comparing the present situation to the previous analysis of 2012 carried out by Nussbaumer et al. (2012) in their study titled "Measuring energy poverty: Focusing on what matters" , the situation has not significantly changed. The main indicators to determine the intensity of energy poverty and the headcount ratio are categorized under modern cooking fuel, indoor air pollution, and electricity access for lighting, household appliance ownership, entertainment and education appliances and telecommunication means. Energy required for mechanical power and transportation needs is not included in the analysis even though they contribute to energy poverty. This is mainly due to the

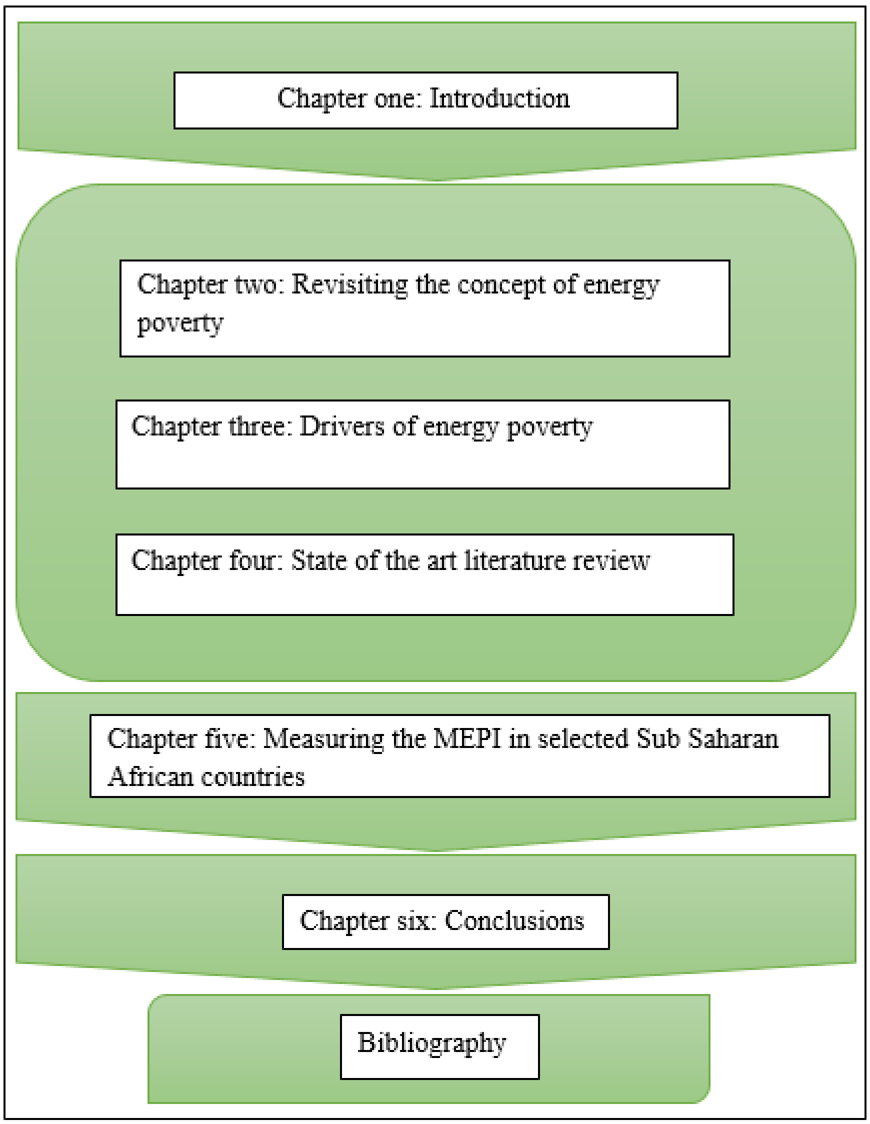
[1] Specifically household survey, which is primary data collected using different types of questionnaires

[2] See dhsprogram.com

fact that appropriate and reliable data for measurement is not available for most of the countries under observation. Including this dimensions, it will interfere with the aspects of comparability between these countries if some represent these dimensions and others do not. This study is intended to determine the current level and the trends in energy poverty for these countries.

Figure 1 below outlines the content flow, through which this dissertation is structured.

Figure 1: Table of contents



Source: Author

Chapter 1 introduces the dissertation, outlining the research objectives and justification of the study. It presents the problem statement and briefly describes the methodology of the study. It explains the scope, boundaries and finally the research structure.

Chapter 2 revisits the concept of energy poverty. It provides an explanation of the current state of energy poverty and the future outlook. It explains energy poverty from different perspectives.

Chapter 3 examines the drivers and influencing factors of energy poverty.

Chapter 4 is literature review based on scholarly work that has been done on various aspects of energy poverty.

Chapter 5 investigates energy poverty in thirty (30) Sub Saharan African Countries. It explains the methodology adopted for this study and the results of the data analyzed. Also, sensitivity analysis and uncertainty analysis are provided. It further demonstrates a comparison between the countries under analysis and the trends in energy poverty. A vivid discussion on the findings is presented.

Chapter 6 provides the conclusion of this study.

CHAPTER TWO: REVISITING THE CONCEPT OF ENERGY POVERTY

2.1 Energy poverty from different perspectives

Blurring a sustainable future today is the problem of security of supply and climate change which has been the main focus of many governments and international organizations. However, presently the energy sector faces an overwhelming problem which is the lack of access to energy termed energy poverty. This over-bearing challenge infringes on human development and wellbeing as well as on human rights and priorities. Much attention has not been paid on the challenge of energy poverty of the world poorest people as stated by (Birol, 2007). For living conditions of the poor to be improved, it involves supporting them to fulfill their elementary needs. Considering the magnitude of the energy poverty problem affecting an extensive population of the world, as seen on the current situation of energy poverty from the IEA/ WEO 2015 publication, approximately 1,2 billion people are living without access to electricity and 2,7 billion people relying on biomass for cooking in 2013. With such alarming numbers, energy poverty need not only to be mitigated but also eradicated. In order for this imperative situation to be tackled, various definitions and characterization of energy poverty from different perspectives has been laid down in literature.

Barnes et al. (2011) refer to energy poverty as:

"the point at which people use the bare minimum energy (derived from all sources) needed to sustain life. Above this point, energy contributes to greater welfare and increasingly higher levels of economic well-being (as electricity and other modern energy sources become more available). Below this point people are not using enough energy to sustain normal lives".

This approach is based on level of household energy demand for the total and end-use energy, basically, how people actually consume energy, based on local resource conditions, energy prices, and policies. It focuses on the energy poverty line concept[3] and how people change their energy use with changes in their income level.

From a social point of view, energy poverty has been defined as the lack of ability to access a level of domestic energy services that would allow a household to take part in the customs and practices that defines membership of society (Bouzarovski S. , 2014).

Also, access to energy services from literature has been established as strongly correlated to development as stated by Nussbaumer et al. (2013); Barnes et al. (2011); IEA, UNDP, UNIDO (2010); Modi et al. (2005). A statistical analysis was carried out by Nussbaumer et al. (2013) establishing the link between energy and the millennium development goals (MDG), recognizing the importance of policy targets in meeting this goals. Despite these linkages energy development in many countries especially in Africa remains disapprovingly low today. Energy services may not reduce poverty but it is an important ingredient to development and wellbeing. Owing to the importance of energy in achieving success to MDGs and upon their expiration, UN General Assembly proposed a set of global Sustainable Development Goals (SDGs) which comprises 17 goals and 169 targets. Some SDGs build on preceding MDGs while others incorporate new ideas. The new SDGs set from 2016 have included energy access as an important element to be achieved. It advocates as number one goal, no poverty of any form, where living on less than $1.25 a day will be completely eradicated, Goal number seven is to ensure access to affordable, reliable, clean energy for all, promoting investments in renewables and energy efficiency while reducing the use of fossil fuels to combat climate change problems (United Nations, n.d.). With the novelty of these SDGs, there is a need for new indicators and a lot of conceptual and methodological work rather than merely the production of new social, economic and environmental statistics to implement this goals (Hák et al., 2016).

From a broad angle, Reddy A (2000, p. 44); Wang et al. (2015) defines energy poverty as the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development. From the perspective of final energy users, what really matters is not the energy consumption *per se* but

[3] Energy poverty line is based on how much energy consumption is necessary to maintain a bare minimum livelihood for households. (Barnes, khandker, & Samad, 2010)

rather the ability to perform energy services such as heating, lighting, commuting, etc., with appropriate energy supplies. Understanding this fact is fundamental in order to assess and address issues related with energy poverty, reasons why, just enabling access to energy supplies alone does not solve the problem when users are limited by affordability in terms of high prices and reliability of the energy system hindering the means of performing the desired services. This definition encompasses the major attributes to the energy poverty problem which is – Accessibility, Availability, Affordability and Reliability.

From the same standpoint, Bazilian et al. (2014) assess energy poverty focusing on the needs of the poor and how elements of energy poverty are being governed across national, regional and local scales. They look at access as much more than physical availability but it must be complemented with affordability. They advanced that available energy services can be made affordable to poor households through tailor-made prices to match the income of the poor or financing investments in energy services for the poor through bill payments, lease and access to the use of renewable energies. The reliability of the energy system is of utmost importance, meaning it must have the capacity of meeting the demands by the end users (Reddy B. , 2015) also providing a safe and acceptable quality of services. (Bazilian et al. (2014).

In another study, Bouzarovski et al. (2015) established their understanding of energy poverty as being vulnerable to a socially and materially required level of energy services at home due to already existing conditions. With this in mind they carried out their research in Hungary, exploring the following:

1. The embeddedness of energy poverty in socio-spatial path dependencies and reform approaches,
2. Its influence on the structure of energy demand as a result of household practices in particular; and
3. The manner in which domestic energy deprivation has shaped the conduct of political debates and government decisions.

These categorization of energy poverty stems from the fact that the authors found the need to explore how energy poverty is embedded in the broader system of infrastructural provision and institutional change while simultaneously affecting both the consumption structure and state policies that characterize energy flows (Bouzarovski et al., 2015).

Contrary to the notion of Bouzarovski et al. (2015), Sovacool et al. (2012) analyzed energy poverty from the dimension of four different energy services- lighting, cooking, mechanical power and mobility which is part and parcel of our daily existence. Practical examples exist in some developing countries where experiencing black outs is a routine. The insecurities associated with inaccessibility of minimum required energy supply has become a norm in these countries and the collection of traditional biomass has designed daily habits which are exhausting and time consuming. These precludes households from other productive activities. Energy required for cooking and lighting is frequently discussed in energy poverty related discussions and analysis. Concerning the last two services, mechanical power (in this case pumps for irrigation or machines to process harvest) and mobility (for commuting) very little has been done in literature addressing them only to a certain extent. Sovacool et al. (2012) came to the conclusion that it is essential to view access to energy not mainly as a problem that can be solved by better technologies and the increase of infrastructures.

Furthermore, Sher et al. (2014) cited the World Economic Forum's definition of energy poverty as: "The lack of access to sustainable modern energy services and products". In their consideration, a person is energy poor if he or she do not have access to at least:

(a) the equivalent of 35 kg per capita per year of LPG from liquid and/or gas fuels for cooking or from improved supply of solid fuel sources and improved (efficient and clean) cook stoves and

(b) 120 KWh electricity per capita per year for lighting, access to most basic services (drinking water, communication, improved health services, improved education services and others) plus some added value to local production. Using these measurements, they quantified the benchmarks for being in energy poverty. These measurements are not entirely correct, given that energy poverty is multidimensional and evaluated from different contexts.

The intensity of energy poverty differs on a national or regional basis. This has contextualized energy poverty depending on the realities of the situation at hand and the driving forces behind it. One thing which holds true throughout the different definitions and context of energy poverty is the fact that data is indispensable for its analysis. To amplify the recognition of energy poverty as a genuine social problem a national definition must be established and more comprehensive quantitative and structural data must be gathered (Berger, 2012). Moreover, measurement tools are required to reinforce policy delivery and formation.

The EU electricity and gas directives of 2009 forces Member States to define the concept of vulnerable customers. It stipulates among other things, the prohibition of disconnection of electricity / gas to such customers in critical times (Mayer & Dubois, 2009). Taking this into consideration, several European countries (Italy, Austria, Malta, Spain, and Cyprus) are in the processes of defining energy poverty in their countries in order to undertake further actions towards eliminating it. Only the UK has been able to provide an official definition stating that "a household is in a situation of fuel poverty when it has to spend more than 10% of its income on all domestic fuel use, including appliances, to heat the home to a level sufficient for health and comfort." (EPEE, n.d). Given the disparities in terms of climatic conditions, heating methods and income assessments, which exist in different countries, other EU nations may not adapt to the UK definition of fuel poverty. Other writers have proposed a more compliant definition which is flexible enough for countries to adapt to their specific state while retaining a common view of the problem. John Hills (2011) proposed one of such definition as fuel poverty occurring when households are unable to heat their homes to suitable standards at a reasonable cost (Hills, 2011). Similarly, EPEE defines "fuel poverty –in effect where a household finds it difficult or impossible to ensure adequate heating in the dwelling at an affordable price"**.** This is adopted from the Brenda Boardman's 1991 definition of fuel poverty from his book titled *Fuel Poverty: From Cold Homes to Affordable Warmth*, focusing on the amount households would need to spend to keep their homes in acceptable conditions with regards to warmth (Teller-Elsberg et al., 2015). Some studies have adopted a precise threshold to define the point at which households are considered to be in fuel poverty. Some use the 10% rule which applies when consumers spend more than 10% of their income on energy services which was directly adopted from Boardman's 1991 definition while others use twice the median concept (Hills, 2011).

New Zealand has adopted the 10% rule above but adding a second indicator which is described as a self-deprivation or not being able afford fuel as a result of low income, energy inefficient housing and high energy prices (Lawson et al., 2015). This poses a negative impact on health, mental wellbeing and general quality of life of those involved. Suggested remedies proposed to alleviate the problem includes improving the energy efficiency of housing which is also a means of promoting carbon reduction (Hills (2011); Legendre et al. (2015)). The England's Warm Front Home Energy Efficiency Scheme from 2000 to 2013, implemented this remedy registering enormous success with a customer satisfaction rate of 92.3% despite the numerous challenges faced by the scheme (Sovacool, 2015).

In another context, and with the existing difference in climatic conditions between developed and developing countries, most African countries do not worry about keeping their homes warm but they are more concerned about energy provision for lighting and cooking. But with the prevailing low electrification rates in developing countries especially amongst rural populations, a lot of studies have brought forward tangible solutions to meet this need. Electricity meets a large proportion of end uses and it allows people to perform economic and education (studying) activities for longer periods even after nightfall. Most of these solutions are centered on rural electrification through decentralized renewable energy capacities such as mini hydro grids, hydro grids and Photovoltaic (PV) connections.

Kaygusuz (2011) establishes that electricity is an expensive, high-quality energy source that practically all rural people want but are prevented from due to constraints of affordability, accessibility and in most cases its availability in the first places. In addition, capital-intensive technological interventions are needed to transform primary energy to electricity which is considered qualitatively superior having the capacity to satisfy an entire range of energy end-uses, something that no other energy form can. This can be accomplished through national grid extension, mini-grids, isolated generator systems and through renewable energy systems such as solar PV, wind power, small hydropower, and bio-fuel engines (Yaw, 2009).

More attention has been given to technological developments towards supplying electricity needs but little has been done concerning the use of traditional fuels for cooking. Biomass is the primary source of fuel for domestic use in developing countries and despite its growing scarcity, firewood is predominantly used. Other sources of traditional fuels include crop residues, dung, saw duct and charcoal. The use of these traditional energies causes a greater problem which is associated with the means through which this fuels are collected and burnt or the appliances used (three stone fire places, highly inefficient stoves) and the surrounding environment (in poorly ventilated rooms in households, separate room or open air) in which it is used. Substances generated from incomplete combustion of firewood or charcoal when trapped in enclosed spaces can have serious health effects resulting from pollution like chronic respiratory diseases leading to pre-mature death (Iddrisu & Bhattacharyya, 2015). Since biomass happens to be the major source of cooking fuel, users are torn between the effects of consuming it or to stay without cooking food for their families which displays the challenge encountered by this populations. However, conventional technologies such as cook stoves, biogas units, heating and cooling systems, and other less eccentric means have been developed over the years. Even though these technologies affect the greatest number of people and have the most substantial impact on the environment in everyday life, they have not been the primary focus of researchers (Sovacool et al., 2012).

In another development, Treiber et al. (2015), having the energy ladder concept[4] in mind and using Kenya as a case study, looks at energy poverty alleviation in the dimension of increasing choice of fuels and stoves. In this case, households use various sources of fuel and multiple cooking stoves to solve the problem of accessibility and availability. According to their findings, this practice was mainly conceived to ensure security of fuel supply in off seasons (e.g during the rainy season when dried firewood becomes scarce) for a particular fuel choice and to manage time by cooking simultaneously with the use of more than one stove. Other authors remarked that this process makes it difficult to spread stove technology but it also gives room for households in developing countries to gain energy security and greater efficiency in their consumption.

Furthermore, Mayer et al. (2014) looks at energy poverty through the lens of energy cost in housing and transport sector. Households in rural areas are prone to energy poverty and are likely to face increase cost due to mobility reasons given that they consume more in transportation than those in urban vicinities. Households in this situation are vulnerable due to disproportionately high energy costs. Similarly, the transportation of traditional fuels increases the cost on these households.

---

[4] Illustrates that energy mix varies significantly between poor and rich, lower income people tend to use more traditional energies to meet their needs but higher income groups tend to move up the energy ladder making use of more commercial energies and less traditional energies. (Bhattacharyya, 2011). The energy ladder concept has continuously been amended based on rapid urbanization in developing countries changing fuel transition patterns and multiple fuel use by households in contrast to single-fuel use as stipulated by the original model (Horst & Ã, 2008).

On a final note, judging from the differences in perspectives on the concept of energy poverty by the different authors discussed above, it can be seen that the disparities occur depending on the needs for energy services and most importantly the drivers behind energy poverty considered in every scenario. In developed countries, these drivers (mainly household's income, energy prices and energy efficiency) are fewer than in developing countries having a large range of drivers (this will be discussed in the next section below). Energy poverty or fuel poverty as termed by some nations is looked upon from different perspectives as discussed above. This entirely depends on the context on which it applies and what is understood by the user.

2.2 Current situation on energy access

Accessibility to clean and modern energy services is vital to human development. In the last few years, many developing countries in the world have taken major steps in expanding electrification and clean cooking fuels to people. In most cases success has been registered through rural electrification programs implementing off grid electrification with the use of renewable energy sources. These least cost solution for a rural off-grid electrification may consist of solar home systems (SHS) or mini-grid connection. Solar Photovoltaic (SPV) systems have been the fastest growing energy technology presently implemented in most of these countries (Yaw., (2009); (Pereira et al., (2009)). In the dimension of clean/efficient cooking fuel programs, the promotion of improved cook stoves and biomass derived liquid fuels, which can potentially reduce health cost and mitigate GHG emissions (Bhattacharyya, 2011), has been instituted. Examples can be seen in china, Bangladesh, Pakistan, Brazil and many other energy poor countries (IEA, March 2010).

2.2.1 Electricity access

Still in many regions of the world, having access to electricity is an extravagance for poor people. According to estimations of the International Energy Agency (IEA) by 2013, 1.2 billion people did not have access to electricity worldwide (Table 1). And even though there have been important advances during the last decade for closing this enormous gap, considering that the number of people lacking electricity by 2000 was estimated in about 1.64 billion. Lack of electricity access is an overwhelming issue when vast populations located in rural areas, 30% of the people living in the countryside worldwide, live without electricity which is just 2% difference from the 2012 analysis (IEA, 2014).Yet African countries such as South Sudan still have 1% national electrification rate and others like Burundi and Sierra Leone with national electrification rates as low as 5%. Analyzing the disparity between rural and urban electrification rates, it is very evident in Sub-Saharan Africa according to the latest estimates by the IEA/WEO energy access database 2015, as glaring in countries like Gambia, Kenya and Congo where the gap between rural and urban electrification rates are very large. In 24 countries in Sub-Saharan Africa the rural electrification rate was less than 10%. According to (Guruswamy, 2016), Energy poverty is concentrated in the Least Developed Countries (LDCs), the nations singled out by the United Nations (UN) for their low income, high vulnerability to economic and environmental shocks, and small and geographically remote economies despite its richness in primary energy resources. The Energy Poor also reside in middle-income Southern nations, such as China, Brazil, and India, where their plight is often obscured by the rapidly increasing consumption levels of the middle class and the elite. Table 1 below shows the electricity access rate in 2013 for both developing countries and transitioning economies and OECD.

Table 1: Electricity Access in 2013 –Regional aggregates

Region	***Population without electricity*** *millions*	***Electrification rate*** *%*	***Urban electrification rate*** *%*	***Rural electrification rate*** *%*
Developing countries	***1,200***	***78%***	***92%***	***67%***
Africa	*635*	*43%*	*68%*	*26%*
Developing Asia	*526*	*86%*	*96%*	*78%*
Latin America	*22*	*95%*	*98%*	*85%*
Middle East	*17*	*92%*	*98%*	*79%*
Transition economies & OECD	***1***	***100%***	***100%***	***100%***
WORLD	***1,201***	***83%***	***95%***	***70%***

Source: (IEA, WEO, 2015)

According to figures released by IEA (2014) for 2012 data, 11 countries –India, Nigeria, Democratic Republic of Congo, Ethiopia, Kenya, Tanzania, Bangladesh, Indonesia, Myanmar, Philippines and Pakistan- accounted for more than 65% of the world´s population lacking access to electricity. There has been some slight improvements to the national electrification rates of some of these countries like India, Philippines and Pakistan recording improvements in electricity access for both rural and urban populations in 2013. At a country level, the latest estimates confirm the progress that China and Brazil have made over many years in increasing access to electricity and that they are now at 100% national electrification rate hence achieving the goal of universal electrification.

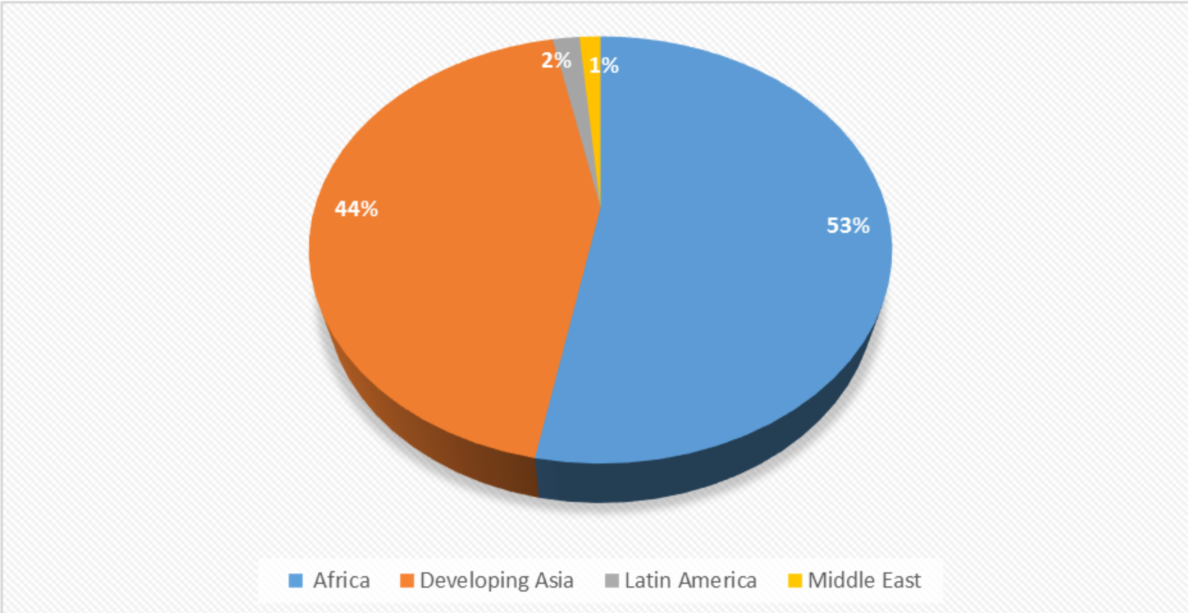


Figure 2: Regional distribution of population lacking access to electricity by 2013 (IEA, WEO, 2015)

Figure 2 above demonstrates that the problem of access to electricity is concentrated basically in two regions of the world. Around 635 million (53% out of 1201 million) corresponded to Africa, and more concretely to Sub-Saharan region. This demonstrates an increase in the number of people and percentage covered without access to electricity as compared to 2012 data, therefore Africa is worse-off than the previous year. In developing Asia, 526 million in 2013 as compared to 620 million people in 2012, did not have electricity in their premises with a percentage drop by 4%. Middle East and Latin America were better off accounting 2% or less. Trends since 2000, have demonstrated that around two-thirds of the people gaining access to electricity have been in urban areas and the population without electricity access has become more concentrated in rural areas.

2.2.2 Traditional use of biomass for cooking

An important indicator for referencing energy poverty is the percentage of population using biomass for preparing food but calculating this index with precision is always complex due to (1) the dispersed distribution of those groups of using such fuels and, (2) because it is difficult to measure the use of a fuel that to a great extent is not exchanged in the market, fuel that can be collected "for free." This also is the major cause to data paucity in most countries for adequate analysis.

By 2013, about 2.7 billion people worldwide used biomass for cooking IEA 2014. Again, most of the population using biomass for cooking by means of highly-inefficient stoves in poorly ventilated spaces, concentrates in Africa, approximately 754 million from 730 million in 2012, but that index was even more alarming in developing Asia with 1895 million in comparison to 1875 million people in 2012. India alone accounted 841 million people and China accounting 450 million people depending on biomass for cooking by 2013. Biomass will continue to dominate energy demand in developing countries in the foreseeable future and this is justified by the growth in the population relying on biomass for cooking over the years.

Table 2: Population relying on traditional use of biomass for cooking in 2013

Region	**Population relying on traditional use of biomass** millions	**Percentage of population relying on traditional use of biomass** %
Developing countries	**2,722**	**50%**
Africa	754	68%
Developing Asia	1,895	51%
Latin America	65	14%
Middle East	8	4%
WORLD	**2,722**	**38%**

Source: (IEA, WEO, 2015)

From the total number of people using biomass for cooking by 2013, the regional distribution reveals that 70% was scattered across countries in developing Asia and, the share of African countries corresponded to 28% (fig. 2). Even though the low proportion of Latin America (2%) compared to other regions, an important number of people, 65 million, still used biomass. In this sense, even when some of those populations have access to modern fuels-such as LPG, natural gas, biogases, etc.-they continue to use traditional fuels (Bhattacharyya, 2011).

The three main determinants in the transition from traditional to modern energy use are fuel availability, affordability and cultural preferences. Biomass in perceived as free and readily available in most areas. The incessant use of traditional biomass for cooking can be justified by the fact that, even when traditional fuels are purchased it is likely to be cheaper than modern fuels, the energy-use appliances (LPG stoves and LPG bottles) needed may hinder transition and lastly the use of biomass in preparing specific cultural dishes like kati-kati in Cameroon which can only be prepare using firewood.

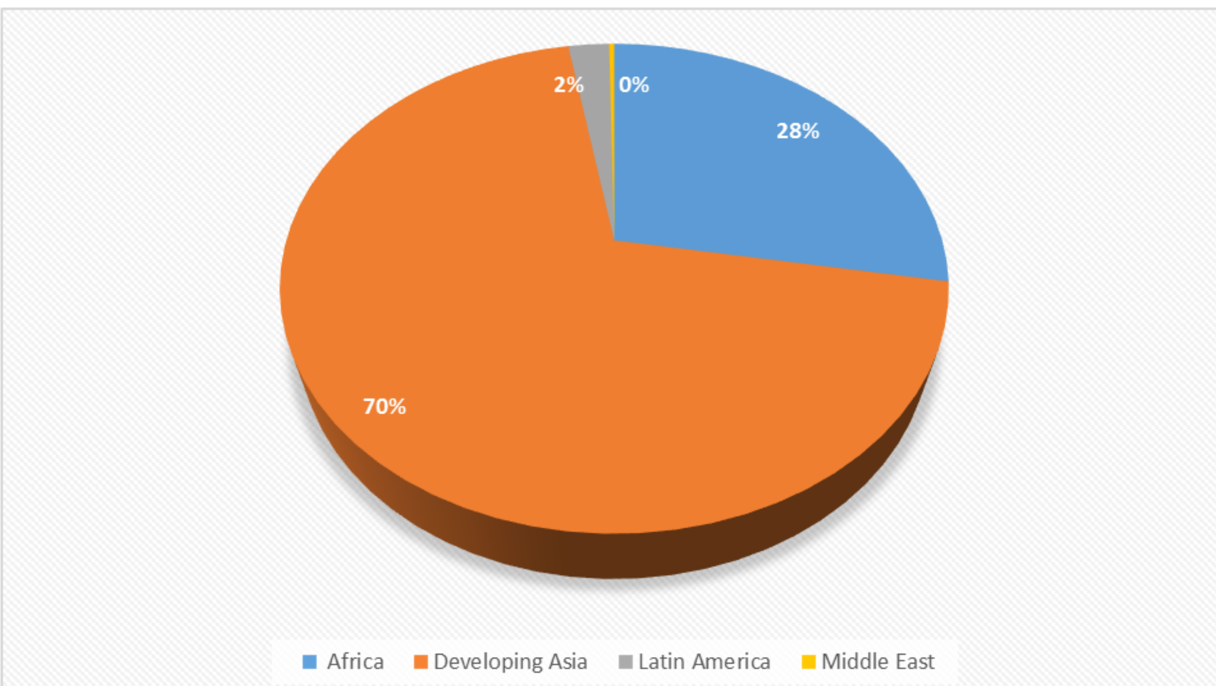


Figure 3: Regional distribution of population relying on traditional biomass for cooking (IEA, WEO, 2015)

The graph (*Figure 4*) below demonstrates the energy access situation for some selected countries in Sub-Saharan Africa.

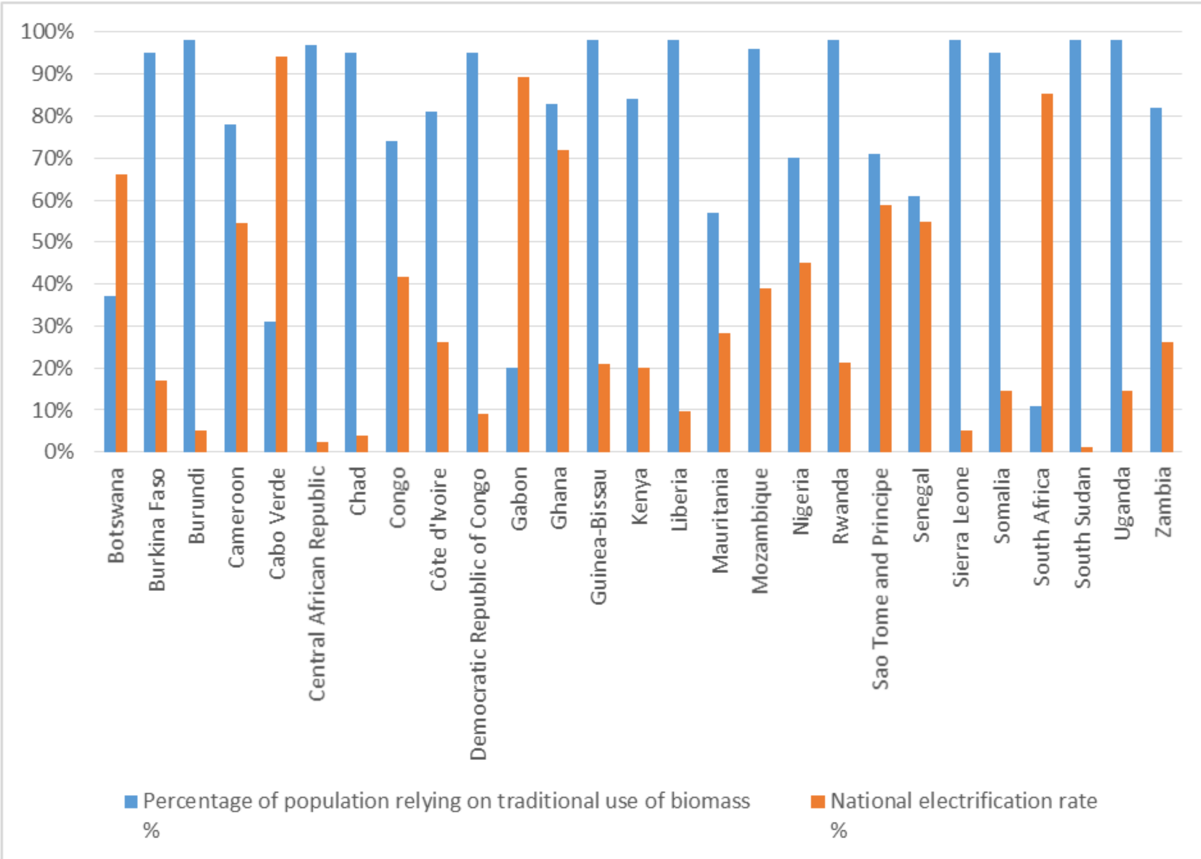


Figure 4: Energy access situation in selected Sub-Saharan African countries (IEA, WEO, 2015)

2.3 Future outlook on energy access

According to Brazilian et al., (2012) there is a huge disparity in energy use and approximately the poorer three-quarters of the world's population use only 10% of the world's energy. Progressively, many countries, especially in developing world have made advancement in energy infrastructures by making Investments in additional generation capacity, extension of the electricity grid in urban areas, mini-grids in medium-sized settlements, decentralized installations providing thermal, mechanical and electric power in rural areas, maintenance and upgrading of existing infrastructure to enhance energy access. Nonetheless, recent estimates by IEA factsheet on global energy trends 2015 states that around 810 million and 550 million people in the world remain without any access to electricity in 2030 and 2040 respectively – the majority of them in sub-Saharan Africa. In the accessibility of energy for cooking dimension, 1.8 billion people by 2040 still depend on biomass for cooking with Developing Asia ranking highest in this classification.

During the last two decades, millions of people have gained access to modern energy, particularly in China and India, due to national economic growth, urbanization and energy access programs .Approximately 75 million people per year are gaining access. Nevertheless, decisive policies to tackle the lack of electricity access and eradicate increase dependence on biomass for cooking are needed. Otherwise, projections for 2030 suggest that the number of people lacking access to modern forms of energy is not going to significantly change (WEO, 2002), Bazilian et al., (2010). Mainly due to rapid population growth, urbanization, policy and institutional development in developing countries (Panos et al.,2015).

The goal to achieve universal access to modern energy services by 2030 requires investments in this sector. In developing countries, investment is needed for additional generation capacity, extension of the electricity grid in urban areas, mini-grids in medium-sized settlements, decentralized installations providing thermal, mechanical and electric power in rural areas and for the maintenance and upgrading of existing infrastructure (WEO 2012).

The obstacles to widespread energy access, specifically electricity access, are largely well known (i.e., financing, planning, governance, and human and institutional capabilities), yet not trivial to overcome. While there are no fundamental technical obstacles preventing universal energy access, there is, however, a lack of effective institutions, good business models, transparent governance, and appropriate legal and regulatory frameworks (IEA, WEO, 2015).

Summarily, the current situation and future projections on energy poverty may worsen if positive steps are not taken to eradicate this problem. A lot has been done by governments and international organizations on providing solutions but a lot still needs to be done. That notwithstanding, every individual has a role to play in making the fight against energy poverty or the fight for energy access a success.

CHAPTER THREE: STATE OF THE ART LITERATURE REVIEW

The purpose of the literature review presented is to provide evidence of knowledge gap that justifies the need for this work; and also to provide support for the methodology used in the study and is a source of information for comparison, triangulation and referencing. Given the above purpose, we use the literature to show the limitations of existing studies. The table below summarizes some existing research on the topic of energy poverty or related concepts which is important to this work.

Table 3: Literature review

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusion	case study
Pachauri & Spreng (2003)	Energy use and energy access in relation to poverty.	How access and use of energy are related to poverty and different approaches to how energy poverty might be measured.	Can energy serve as a useful measure for poverty? Method: Energy use- access matrix	Consumption dimension includes non-commercial consumption. The access dimension can serve as an indicator of the opportunity to join the modern market economy.	To improve the wellbeing of the poor requires improving access to efficient energy sources and to ensuring that they get an adequate quantity of energy by making it affordable. An energy policy that takes poverty reduction seriously must subsidize energy infrastructure expansion to poor areas rather than the energy itself. This might even be financed by a tax on energy use.	Households in general
Pachuari et al. (2004)	On Measuring Energy Poverty in Indian Households	Presents a novel two-dimensional measure of energy poverty and energy distribution that combines the elements of access to different energy types and quantity of energy consumed.	Assessing the extent of energy poverty and changes in energy distribution patterns.	The analysis shows a significant reduction in the level of energy poverty and a rapidly developing sub-continent. The new measure is a good complement to conventional monetary measures and is general enough to be applied to other developing countries.	The provision of energy, by itself, cannot improve well-being in every case, and it is clearly important that other concerted actions and direct policies and measures be implemented to improve the lives of the poor through the spread of literacy, healthcare, employment and other income generating options. This will require significant additional efforts and large investments in infrastructure expansion in the next years.	India

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusion	case study
Pereira et al. (2009)	Rural electrification and energy poverty: Empirical evidences from Brazil	Evaluate the impact of rural electrification on the reduction of energy poverty in Brazil	Using the energy poverty line with sample survey data and Own elaboration based on the IMPAR Version 2.3 System	Results indicate a fast change in the profile of energy consumption and a reduction of energy poverty.	This new approach works as a complement, among other variables, to analyze and quantify the real economic, social and energy impacts in rural electrification programs, generally applied in developing countries.	Brazil
Yaw (2009)	Solar PV rural electrification and energy poverty: A review and conceptual framework with reference to Ghana	Discuss solar PV, rural electrification and energy-poverty relationship.	Conceptual framework on the relationship between the concepts of solar PV electrification, energy-poverty and quality of life	The energy quality of life framework illustrates how solar PV electrification can be used as a means to achieve socio-economic development through the provision of basic energy services in rural and peri-urban areas.	Future studies should add to the number of indicators that can be gathered from the review with the goal of reducing energy-poverty and enhancing quality of life associated with access to solar PV in rural and peri-urban areas without access to grid-electricity.	Ghana
Kaygusuz (2011)	Energy services and energy poverty for sustainable rural development	(1) Identify problems encountered in the social–economic infrastructure as related to rural energy development and assess the current energy generation and consumption rates.	/	Energy services for poverty reduction are less about technology and more about understanding the role that energy plays in people's lives and responding to the constraints in improving livelihoods.	Energy is needed for household uses, such as cooking, lighting, heating; for agricultural uses, such as tilling, irrigation and post-harvest processing; and for rural industry uses, such as milling and mechanical energy and process heat. Energy is also an input to water supply, communication, health, education and transportation in rural areas.	Rural households in developing countries

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusion	case study
Pereira et al. (2011)	The challenge of energy poverty: Brazilian case study	Evaluate the impact of rural electrification on energy poverty in the context of government policies aimed at promoting energy equity.	Evaluate the effectiveness of recent efforts in Brazil to expand access to electricity.	Access to electricity on a regular and secure basis enabled a change in energy reality for the population studied, reducing energy poverty and inequality, are motivating, so the continuity of government efforts in rural electrification policies particularly for isolated communities.	The strategy of combating energy poverty through programs of rural electrification is efficient. Providing access to energy is therefore an appropriate component of strategies to reduce in equality and improve the quality of life of those who remain on the outer edges of society. Rural electrification leads to a significant reduction of energy poverty level and a consequent improvement in energy equity.	Brazil
Bhide & Monroy, (2011)	Energy poverty: A special focus on energy poverty in India and renewable energy technologies	To bring to light the problems faced in India in terms of energy consumption as well as the hindrances faced by renewable-based electrification networks.	Analyze the possibility of a solution to the problems of finding a sustainable method to eradicate energy poverty in India	The Government's measures such as the setting up of the Ministry of New and Renewable Energy Sources show their intent of having renewable energy sources play an important role in the further electrification of the country, and in the eradication of energy poverty.	The Government will have to be more aggressive in the promotion of renewable energy technologies in order to achieve sustainable development in India. Also, by making electric power accessible, increasing the reliability of quality of power and its efficiency at reasonable rates ensuring the eradication of energy poverty	India

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusion	case study
Barnes et al. (2011)	Energy poverty in rural Bangladesh	How energy interventions might contribute to reducing poverty.	Is the lack of modern energy a cause for poverty? Does energy improve household welfare?	Findings suggest that some 58 percent of rural households in Bangladesh are energy poor, versus 45 percent that are income poor. -policies to support rural electrification and greater use of improved biomass stoves might play a significant role in reducing energy poverty.	The use of an energy-poverty indicator can signify how well or poorly a country such as Bangladesh is performing in meeting the basic needs of its poorest households. This can help track the effectiveness of the impact of a wide variety of energy programs, including sector reforms, electricity generation projects, and the promotion of high-quality cooking fuels.	Rural Bangladesh
Rudge (2012)	Coal fires, fresh air and the hardy British: A historical view of domestic energy efficiency and thermal comfort in Britain	This paper considers the historical context for fuel poverty as a particularly British phenomenon. It examines claims that this is due to the mild climate and low indoor temperature expectations.	Qualitative method	The economics of occupants' heating and cooling needs should be addressed in building design, quality of workmanship and use of materials both in the context of climate change and newly industrialized populations.	The climate, particularly its characteristic changeability, has influenced building and heating methods, and the low priority given to energy efficiency by legislators. Significantly, economic priorities produced poor quality mass housing during the industrial revolution. The availability of coal encouraged the use of open fires, which demanded high ventilation rates. The British do value warmth but older buildings designed for heating with radiant open fires are difficult to adapt to convective central heating.	Britain

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Nussbaumer et al. (2012)	Measuring energy poverty: focusing on what matters	Multidimensional Energy Poverty Index (MEPI) – focuses on the deprivation of access to modern energy services. It captures both the incidence and intensity of energy poverty, and provides a new tool to support policymaking.	Multidimensional Energy Poverty Index	A person is considered as energy poor if, for instance, she has no access to clean cooking or does not benefit from energy services supplied by electricity.	The methodology outlined and tested in this paper contributes to efforts geared towards providing evidence-based information to inform the design and implementation of measures and policies to address the issue of energy poverty.	selected African countries
Berger, (2012)	Energy poverty – from a global perspective to Austria	To show the different scales of and perspectives on energy poverty on various scales (global, European, Austrian or regional)	/	Only by addressing socioeconomically weak groups the problem of the ever rising consumption of energy on the household level can be properly understood and mitigated.	Energy poverty is a good example for the inter-connectedness of the three pillars of sustainability, Social factors, economic (financial) circumstances and the environmental performance of energy poor households cannot be understood or increased by addressing only one or two of the three dimensions. it needs to be included in agendas to tackle the energy consumption	Austria

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Moore (2012)	Definitions of fuel poverty: Implications for policy	Outlines why the definition of fuel poverty is important in policy formulation and describes how the Government's current definitions evolved from the original concept.	/	/	Fuel poverty has many advantages over the existing definition, especially in its treatment of incomes. While not yet finalized, therefore, the Review (Hills 2011, 2012) still provides an opportunity–effectively the first opportunity there has been since the 2001 UK Fuel Poverty Strategy–for developing and implementing a far more meaningful and fairer official definition of fuel poverty.	UK
Liddell et al. (2012)	Measuring and monitoring fuel poverty in the UK: National and regional perspectives	Traces the earliest formulations of the concept, focusing particularly on the 10% needs to spend threshold which was adopted in 1991 and remains in place some 20 years later.	/	The introduction of regional twice-median data would not represent a paradigm shift, but would simply add an additional indicator. The UK rate of fuel poverty would remain unaffected by local twice-medians, whose function would be confined to setting local targets and assessing local implementation efforts.	A national fuel poverty prevalence rate based on a national twice-median is vital for ensuring parity across the regions, especially in the achievement of the long-term goal of eradicating fuel poverty in the UK wherever practical. Without regional thresholds, it is difficult to envisage regions like Northern Ireland being able to demonstrate best practice and value for money in its treatment of fuel poverty.	UK

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Serwaa Mensah et al. (2013)	Energy access indicators and trends in Ghana	It reviews briefly the different types of energy access indicators and analyses access to modern energy in Ghana as measured using the energy access indicators employed in Ghana.	MEPI, EDI Energy access index	/	Ghana has achieved commendable access to modern energy services compared to her sub Saharan peers but recommends further efforts to achieve the set targets of universal access to electricity by 2020 and 50% access to LPG by 2020.	Ghana
Gómez-Paredes et al. (2013)	Energy efficiency to reduce poverty and emissions: a silver bullet or wishful thinking? Analysis of efficient lighting CDM projects in India	It estimates the impact of the expenditure of monetary savings (understood as "poverty alleviation") on the reduction targets of two CDM projects.	Input-output analysis, consumer surveys and rebound effects	Results suggest that the projects may, in fact, reduce electricity consumption further than expected; however, in terms of CO2 emissions, results vary.	Since reducing poverty and greenhouse gasses are among the most important challenges that we face today, and both are needed for a sustainable human society, enhancing energy efficiency in poor households regardless of the size of the rebound seems beneficial. A wider perspective of analysis is needed if energy efficient projects are to be held as a "silver bullet".	India

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Schuessler (2014)	Energy Poverty Indicators: Conceptual Issues Part I: The Ten-Percent-Rule and Double Median/Mean Indicators	Discusses approaches to measuring energy poverty	Fixed Ten-Percent-Rule and Double Median/Mean Indicators	A fixed percentage threshold may be more suitable, provided it is empirically confirmed, adequately modified, and regularly updated.	The double median share threshold endorsed by British researchers is ill-suited for determining energy poverty.	Global application
Sher et al. (2014)	An Investigation of Multidimensional Energy Poverty in Pakistan: A Province Level Analysis	Methodology to measure Multidimensional Energy Poverty (MEP) at provincial level in Pakistan.	Multidimensional Energy Poverty Index (MEPI), proposed by Nussbaumer et al. (2011).	Deprivation is least in the dimension of home appliances for all provinces except Baluchistan which is least deprived in entertainment appliances dimension. Overall indoor pollution, cooking fuel and entertainment appliances are the three major contributors to overall MEP Headcount in all four provinces.	To combat Energy Poverty in most deprived areas by initiating suitable measures. Indoor pollution and cooking fuel being the major contributors to overall multidimensional energy poverty in all provinces of Pakistan, energy poverty in each of these dimensions should be individually addressed in order to reduce overall multidimensional energy poverty.	Pakistan

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Dagoumas and Kitsios (2014)	Assessing the impact of the economic crisis on energy poverty in Greece	Assessing the impact of the economic crisis on energy poverty in Greece.	The capability of people to pay their electricity bills, the power cuts made due to the economic crisis and government policy for sensitive social groups.	It provides evidence that the economic crisis has considerable effect on the electricity consumption and on the capability of people to pay their bills. However, the power cuts depict mainly the unwillingness of customers to continue paying bills for properties that they do not use or do not provide any revenue for them.	To combat Energy Poverty in most deprived areas by initiating suitable measures. Indoor pollution and cooking fuel being the major contributors to overall multidimensional energy poverty in all provinces of Pakistan, energy poverty in each of these dimensions should be individually addressed in order to reduce overall multidimensional energy poverty.	Greece
Walker et al. (2014)	Fuel poverty in Northern Ireland: Humanizing the plight of vulnerable households	Explores this interaction at household level, and the diversity of fuel poverty which results amongst households in Northern Ireland, a region particularly prone to fuel poverty.	Assess energy efficiency and households fuel poverty, whether households would qualify for energy efficiency improvements under current government subsidized schemes, the relationship between eligibility measures and household schemes	The results reveal diversity amongst fuel poor households and, in many instances, households in most severe fuel poverty do not fit the criteria for energy efficiency upgrades, despite standing to benefit from significantly reduced fuel poverty.	The impacts of retrofitting are greatest for those in greatest need, but even the most generous package would leave a considerable number of households in fuel poverty, for which additional policy measures are required.	Ireland

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Wishanti, (2015)	Alleviating energy poverty as Indonesian development policy inputs post-2015: improving small and medium scale energy development	Seeks to measure the Indonesian government concern upon energy crisis and its impact on poverty eradication.	By focusing on the gaps of energy access as the main indicator to measure energy poverty	Identifying the opportunities to build small and medium-scale energy development will be the main source for formulating the policy inputs	By utilizing the national gap analysis, this article urges the needs of investment in small-scale energy development. The investment may collaborate the role of government energy policies with the international private sectors to perform technology proliferation and access. Also proposes the small-scale energy development as a focus of post-2015 development agenda.	Indonesia
Ahlborg et al. (2015)	Provision of electricity to African households: The importance of democracy and institutional quality	Analyze the degree to which the level of per capita household electricity consumption in African countries can be attributed to the countries' democratic status and their institutional quality.	How can differences in per capita household electricity consumption across African countries be understood?	The analysis shows that democracy and institutional quality both have significant positive effects on per capita household consumption of electricity.	An important policy implication that energy sector reform efforts in general and efforts to promote household electrification (e.g., as part of foreign aid) in particular should increasingly pay attention to important institutional constraints and capacity-building efforts. These efforts are thus not only about bringing in the necessary economic resources in terms of financing.	Africa

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Wang et al. (2015)	Energy poverty in China: An index based comprehensive evaluation	Reviews the commonly used energy poverty measurements through classifying them in to three categories: energy service availability, energy service quality, and satisfaction of energy demand for human's survival and development. It also proposes a new index	China's energy poverty comprehensive index	China's energy poverty showed an alleviating trend from 2000 to 2011, and during this period, energy service availability improved slightly; energy consumption cleanliness showed no significant change; energy management completeness decreased with fluctuations; and household energy affordability and energy efficiency improved continually. China's regions show different characteristics of energy poverty.	Proposed solution are increasing investment on energy infrastructure, and spreading energy management organization in rural area; decreasing relative cost on household commercial energy consumption, and encourage the utilization of modern, clean and efficient household energy consumption equipment.	China
Nlom & Karimov, (2015)	Modeling Fuel Choice among Households in Northern Cameroon	Explore economic and socio-demographic factors that influence a household's probability to switch from firewood to cleaner fuels (kerosene and LPG) in northern Cameroon.	Attempts to determine potential factors that influence Cameroonian households to abandon the use of firewood for the benefit of more efficient fuels.	Results indicate a reasonably good prediction of household fuel choices in Northern Cameroon showing there is a potential for a transition from traditional to cleaner fuels in the studied region, this transition is still in its earlier stage.	Firewood and kerosene prices, age of household heads, educational level of household heads and willingness to have a gas cylinder, as well as type of dwelling have a statistically significant impact on fuel-switching decisions.	Northern Cameroon

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
González-Eguino, (2015)	Energy poverty: An overview	Presents an overview on energy poverty, different ways of measuring it and its implications.	Argues that energy and energy poverty need to be incorporated in to the design of development strategies.	Specific policies and programs are required to deal with energy poverty,	Not all investments required to forestall the worst effects of energy poverty involves technology or the construction of large, expensive infrastructures. Educational programs to teach people the best way to use biomass in the home may be an effective, inexpensive way of reducing the worst damage to health, and may entail no more than simple actions such as improving combustion in cookers and ventilation in homes. Funding can also be an effective means.	Global application
Bouzarovski & Petrova (2015)	A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary	An integrated conceptual framework for the research and amelioration of energy deprivation in the home.	Identifies the main components and implications of energy service and vulnerability approaches as they relate to domestic energy deprivation across the world.	Energy services and vulnerability approaches allow for a more explicit focus on the geographic aspects of domestic energy deprivation, as dimensions such as energy access, flexibility, efficiency and needs are unevenly distributed across space.	Planning frameworks need to be mobilized so as to ensure that some of the broader structural problems surrounding energy service poverty can be dealt with in a systematic and comprehensive manner, alongside fiscal policies to support the low carbon transition.	Developed & developing world

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Reddy (2015)	Access to modern energy services: An economic and policy framework	Investigates the issue of accessibility of modern energy services, evaluates them and identifies various strategies to provide them to the needy households in a cost-effective manner through sustainable energy technologies	The most basic access indicator is coverage of energy services using a combination of three dimensions: (i) availability, (ii) affordability and (iii) reliability comprising both the short and long-term perspective.	Additions of large-scale grid/off-grid connected electricity as well as community biogas for various economic and governance-related reasons will benefit the poorest communities, which reside in slums or sparsely populated rural areas.	The suggested framework helps the policy makers to identify technologies that are better than others under the present conditions. Implementing and scaling up the energy demand requires collaboration among various actors like households, local bodies, energy utilities, governments, entrepreneurs, research organizations, non-governmental organizations, community groups, financial institutions, and international agencies.	India
Ong (2015)	Choice of Energy Paths: Its Implications for Rural Energy Poverty in Less Developed Countries	This study recasts the relationship between energy regimes and energy poverty, by drawing on perspectives from energetic theory and environmental inequality.	Ordinary least squares regression (OLS)	Renewable energy does exert a positive effect on rural electrification in the countries studied. In addition, higher gross national income (GNI) per capita and use of conventional fuels are found to relate positively to rural electrification.	Besides the prospects of renewable energy to mitigate rural energy poverty, committed investments into the renewable energy sector are likely to enhance its cost-effectiveness over the long run. Use of renewable energy is thus ultimately expected to be a sustainable solution to the issue of energy security and rural energy poverty.	138 developing countries

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Treiber et al. (2015)	Reducing energy poverty through increasing choice of fuels and stoves in Kenya: Complementing the multiple fuel model	The objective with this paper is to contribute new knowledge to contemporary theory on energy transition in developing countries by building on empirical evidence from Kenya.	/	The linear model predicts a positive relationship between socioeconomic development and transition to more efficient, cleaner, and costly energy sources.	Multifaceted demands of the households are an important driver of the diversification. Preference often concurs with the most efficient and best available stove and fuel for a particular task. Individual characteristics and social and cultural tradition influence the final choice.	Kenya
Phimister et al. (2015)	The dynamics of energy poverty: Evidence from Spain.	Understanding of the routes in to and out of energy poverty and to know how energy poverty is distinct from income poverty, therefore justifying the need (or otherwise) for separate policy measures and priorities.	Uses longitudinal data to examine the level and dynamics of energy poverty in Spain, comparing the results to the level and dynamics of income poverty.	Results show clearly how mitigating expenditure behavior reduces the level and alters the dynamics of expenditure-based energy poverty compared to subjective energy poverty. The results suggest that it is harder to exit subjective energy poverty but also it is easier to enter subjective energy poverty than expenditure-based energy poverty.	The analysis of the study has provided several new insights into both the relationship between energy poverty and income poverty, and the dynamics of energy poverty. These insights are useful in relation to designing and monitoring the effectiveness of energy policies.	Spain

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Iddrisu & Bhattacharyya , (2015)	Sustainable Energy Development Index: A multi-dimensional indicator for measuring sustainable energy development	As energy plays a vital role in the modern lifestyle of any country reviewing the comprehensive-ness of existing metrics in tracking and tracing energy sustainability.	MEPI, EDI, Energy sustainability indicator a composite index, SEDI (Sustainable Energy Development Index), to fill the gap.	It is found that SEDI has a positive correlation with both the Human Development Index (HDI) and the Energy Development Index (EDI) but provides a better understanding of the different dimensions of energy sustainability	The existing multi- dimensional indicators do not capture the sustainability dimension adequately. Thus, overall, the SEDI can be a good addition to sustainable energy metrics toolbox on the path to sustainable development.	Developing countries
Scarpellini et al. (2015)	Analysis of energy poverty intensity from the perspective of the regional administration: Empirical evidence from households in southern Europe	A need to intervene by the increasing number of households facing energy poverty due to limitation of affordability to energy services caused by the current economic situation in Europe	Intensity of energy poverty in the studied cases is examined by measuring the percentage of energy expenditures with respect to income in the households that suffer it, and a descriptive analysis of the main determinants of energy poverty in the homes studied and policy implication at regional level are presented.	These households have already accredited their incomes and their inability to meet the energy services. Thus, they will be more vulnerable as the energy costs increase, or when the relationship between their energy costs and their incomes increase. The impact of household energy supply costs (bills) and resident consumption habits do not represent a significant factor in the degree of the intensity of energy poverty in Aragon, except in specific cases.	The results obtained can be applied to the decision-making of the regional government to implement palliative measures, while long-term preventive measures are not being adopted because they require higher budgetary allocation. In this context, domestic consumers affected by energy poverty, in particular, those living on a limited income but with required energy expenditures, should benefit from special pricing schemes to avoid the negative impact of the crisis since they suffer on a daily basis.	Spain

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Ricci and Legendre (2015)	Measuring fuel poverty in France: Which households are the most fuel vulnerable?	This paper estimates the scale of fuel poverty in France under diverse measures and proposes a definition of fuel vulnerability as well as a characterization of the fuel vulnerable households.	Identify fuel vulnerable households as those households that are not ordinarily poor when considering income net of housing costs, but turn poor because of their domestic fuel expenses.	Data analysis indicates that the proportion of fuel poor people and their characteristics differ significantly depending on the fuel poverty measure chosen. The econometric results show that the probability of being fuel vulnerable is higher for those who are retired, living alone, rent their home, use an individual boiler for heating, cook with butane or propane and have poor roof insulation.	A specific policy could be implemented to help households located just below the poverty line to help them shift above it. Providing incentives (financial support) for improving housing energy efficiency, to devote public spending to reduce fuel vulnerability through agreements between the State and some boilers providers, building craftsmen, etc., to propose affordably priced equipment.	France
Roberts et al. (2015)	Energy poverty in the UK: Is there a difference between rural and urban areas?	Whether the incidence and dynamics of energy poverty varies between rural and urban areas in the UK.	Descriptive analysis, discrete hazard models of energy poverty exit and re-entry are estimated and used to explore the impact of an increase in energy price.	The experience of energy poverty in urban areas was found to be on average longer with a higher probability of energy poverty persistence. Vulnerability to energy price increases and the probability of rural residents being trapped in energy poverty for five or more years.	It is argued that a combination of household type and spatial targeting of policy support is required.	UK

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Teller-Elsberg et al. (2015)	Fuel poverty, excess winter deaths, and energy costs in Vermont: Burdensome for whom?	This study assesses the extent and severity of fuel poverty in Vermont. It analyzes energy burdens in Vermont by house hold income deciles.	What could the state legislature, agencies, community groups and energy companies do to address energy and fuel poverty in Vermont?	Approximately 71,000 people suffered from fuel poverty in Vermont in 2000, and in 2012 the number rose to 125,000, or one in five Vermonters. Startlingly, fuel poverty grew 76 % during this period. Excess winter deaths, caused potentially by fuel poverty, kill more Vermonters each year than car crashes.	Suggestions that the Vermont legislature better fund investments in weatherization among low-income households; that community groups and social service agencies scale up the training of energy efficiency coaches; that state agencies endorse improvements in housing efficiency and appropriate fuel switching; and that utilities and fuel providers offer extra assistance for disconnected households and allow for on-bill financing of efficiency improvements.	Vermont
Bouzarovski et al. (2015)	Unpacking the spaces and politics of energy poverty: path-dependencies, deprivation and fuel switching in post-communist Hungary	Explore the recent expansion of energy poverty across different demographic and income groups.	Methodologically, the paper is based on an analysis of changes in the domestic energy “affordability gap” since the late 1980s, thanks to a comprehensive assessment of price and salary/pension indexes	It has transpired that energy poverty has both spatial agency and helps articulate political work, as it forces state and private sector actors to adjust their policies in different ways, while serving as a basis for an entire host of household strategies that challenge hegemonic orders.	The need for developing an explicit conceptual and policy link between domestic energy deprivation and the implementation of housing and climate policies. However, high or increasing levels of domestic energy deprivation complicate the application of policies that promote energy vulnerability-enhancing measures, such as renewable feed in-tariffs or surcharges paid by domestic energy users irrespective of income, needs or living conditions.	Hungary

Name(s) of author(s)/ Date of publication	Title	Goal/Aim	Research question/Method used	Results / findings	Conclusions	Case study
Sumiya (2016)	Energy Poverty in Context of Climate Change: What Are the Possible Impacts of Improved Modern Energy Access on Adaptation Capacity of Communities?	Analyses implications of access to modern energy on environmental and human wellbeing from the perspective of adaptation to climate change.	Describing energy poverty situation and climate vulnerability of Mongolia, Identification of possible direct benefits of modern energy services on improved human, financial and natural capital - crucial determinants of adaptive capacity of households to climatic disruptions.	This goal of reaching full access to modern energy may have two different paths; improve access to energy services through fossil-fuel sourced facilities or clean renewable energy systems. Leapfrogging into cleaner energy systems would be the preferred in the long run, however, this leap would require strong political commitment from both national/receiving and external/providing sides	Now that developing nations are most likely to be included in carbon mitigation agreements, projects improving sustainable energy access could possibly be one of initial carbon mitigating and climate change adaptation actions taken by governments due to its relatively low abatement costs and high return benefits.	Mongolia
Chard & Walker, (2016)	Living with fuel poverty in older age: Coping strategies and their problematic implications	This article draws attention to the ways in which older people on low incomes cope with and adapt to problems of affording to keep warm at home.	/	Four categories of coping strategies were defined and used adjusting the length of time and parts of the home for which heating is kept on, using secondary heating sources; using additional layers that help to keep bodies warm; and adjusting daily routines to get by and to control the size of their energy bills.	Coping strategies raise questions about what are acceptable living conditions, how judgments are made and how assistance can be provided when householders do not themselves problematize their situation. Implications for action to tackle fuel poverty are considered.	England

Table 3 above summarizes and reviews scientific studies carried out on energy poverty, fuel poverty and other commonly used energy poverty assessment indicators and measurements. These studies analyzed above are directed towards energy service availability, energy service quality, and satisfaction of energy demand for human's survival and development. They are further reviewed and discussed on the basis of the definition of energy poverty or fuel poverty adopted by the author(s) and the variables under consideration.

The case studies under analysis differs. Some studies narrow their case studies solely on rural populations of a country because of the high intensity of energy poverty within the rural populations as compared to the urban populations (IEA, WEO, 2015). Analysis are also carried out on a sample population, national levels, regional level or a group of countries.

The sources of data utilized by these studies are mainly from secondary sources. Data sources includes data from national household surveys carried out by governments, agencies or national organizations such as National Sample Survey Organizations (NSSO) or international organizations such as World Bank database, EUROSTAT, International Energy Agency (IEA), Demographic Health Survey (DHS survey) which are reliable data sources appropriate for such analysis.

With each study having a different aim, the methodology and tools for analysis used differs depending on the aim or goal of study, research questions to be answered, and the scope of the research. For this study, the Multidimensional energy poverty index (MEPI) proposed by Nussbaumer et al. (2012) is used. Other methods includes the regression analysis, Econometric models, 10% threshold and twice-median concept, Sustainable Energy Development Index (SEDI) among others which are used in measuring energy poverty and fuel poverty.

Taking a closer look at the findings from the studies analyzed above, demonstrates that fuel poverty and energy poverty exist in these countries but they do not provide the number of people who are considered to be in energy poverty or fuel poverty or how energy poor and fuel poor they are. An exception to this is for the studies using the MEPI methodology (Nussbaumer et al. (2012); Serwaa Mensah et al. (2013); Nussbaumer et al. (2013); Tombofa. (2013); Sher et al. (2014) which specifies the incidence and the intensity of energy poverty for the population studied hence a good tool which provides a support to decision or policy making. These studies also clarifies the causes and effects of energy poverty or fuel poverty and propose solutions on how to combat and eradicate energy poverty where it exist. Similar trends that exist in these scientific studies analyzed above on energy poverty reduction or mitigation is centered around energy efficiency, increase use of modern energy appliances like improved cook stoves, CED lighting systems, fuel transition or fuel switching, rural electrification, investment in energy infrastructures especially renewable energy deployment, investment in new supply sources through grid extensions, hydro grids, diesel generation, photovoltaic (PV) electrification, biogas. On the part of the government, implementing energy policies in their countries and participating in promoting energy efficiency through special pricing schemes for bills and energy efficient appliances. For international organizations, through including energy issues in their agendas as a way forward to creating awareness and tackling energy poverty.

To add to that, there has been a lot of driving forces behind energy efficiency as a solution to combating energy poverty in many countries which is also being promoted by the Kyoto protocol. Clinch and Healy, (2001) in their work demonstrates how energy savings, environmental benefits, health and comfort improvements through energy efficiency can be assessed from energy efficiency programs. They concluded that a perfect method for evaluating large scale efficiency programs is needed and effective household energy efficiency program is beneficial but also it depends on the effectiveness of its implementation.

Furthermore, Improved cook stoves as a solution to reduce pollution, fuel consumption and time spent by women and children in collecting biomass and cooking is a trending solution in most energy poor countries but Shrimali et al. (2011) provides evidences that the unsuccessful efforts by governments and NGO’S in disseminating this improves cooked stoves despite the positive benefits associated to its reduction of pollution, death, cooking time and fuel consumption. The major reasons for these failure is associated to design, customers targeted, financing, marketing channel strategy and organization characteristics. This led to conclusions that in most cases the government plays a vital role in impeding the success of this program through subsidizing fuels rather than through promoting aspects of cultivating stove businesses such as financing research on technologies, grants to start ups and publicizing the dangers of indoor pollution and promoting methods to reduce it. Also creation of standard energy efficiency labels on cookstove to differentiate company's products based on quality performance (Shrimali et al, 2011). As supported by Boardman (2004) such measures lack participation and pull by customers because they may be ignorant of its benefits.

Moreover, Ruiz-Mercado et al. (2011) draws our attention to the fact that the adoption of sustained use of improved cookstove must be monitored to ensure the benefits are feasible. Given that when a household purchases a new stove they do not completely substitute from their previous cooking devices but use each device where it best fits hence the impact of improved cookstove use cannot be weighted. In another development, Troncoso et al. (2011) carried out a study in Mexico which proves that the dissemination and adoption of improved cook stoves warrants the participation of the organization's involved. The organizations does not have to concentrate only on improving their technology but also on educating users on the impacts and use of the devices because only through awareness that people can be motivated to purchase and use these devices.

In another dimension, rural electrification is extensively looked at in literature as a tool in combating energy poverty. This program has been implemented in many countries but the success of this program depends on its reliability, accessibility and affordability. These program amongst others requires huge capital for investment, expertise and continuous monitoring of the system. Such systems cannot efficiently function if customers cannot afford to pay their electricity bills, necessary repairs cannot be effected or if lines are tapped or stolen by vandals. Zero cost methods have also been used such as a solar bottle light[5], "litre of light", which is an interesting concept discovered by a Brazilian mechanic- Alfredo Moser in 2002[6]. By providing light like that of a 50Watt bulb during the day using only a plastic bottle, water, a little bleach to prevent algae and the power of the sun. 15 other countries including Kenya and Philippines (Manila) have taken advantage of this brilliant discovery, lighting millions of homes especially in the slumps (Zobel, 2013).

[5] See https://www.youtube.com/results?search_query=solar+bottle+light

[6] See also https://www.youtube.com/results?search_query=alfredo+moser+bottle+light

To conclude, most of these solutions recommended for energy poverty eradication do not achieve their goals or the extent of their ability and end up being abandoned by the providers for lack of funds and inefficiency in the part of the consumers. Therefore, it is very important to educate the masses on the adverse effects of energy poverty and the benefits of the adoption of good practices to reduce or eradicate the problem. Energy efficiency and demand-side measures in this case play a fundamental role because it is more costly to invest in new supply sources than to invest in energy efficiency.

CHAPTER FOUR: DRIVERS BEHIND ENERGY POVERTY

There are a number of reasons impelling the lack of choice of modern energy supplies either associated with the geographical dispersion of some populations or, related with lack of economic capacity to afford energy supplies not only at the end-user level, but also, at the supply side when governments, especially in developing countries, lack financial means for investing in energy infrastructures which is capital intensive (Pereira et al. 2011). Besides, high risk conditions for succeeding in businesses in many developing countries, prevent private investors to venture in this sector. These drivers differ in developing countries and developed countries but the main drivers of energy poverty which applies in both context are a combination of low household incomes, high energy prices and a low energy efficiency of the dwelling (Boardman, (2010: p. 21); Bouzarovski (2014); Berger (2014); BPIE (2014); EPEE, (n.d); Grevisse and Brynart (2011); Hill (2011: p. 36) ; Mayer et al. (2009); Pereira et al. (2011); Schweizer-Ries (2009)). Some of the drivers of energy poverty are discussed below.

- Low household income

The existence of energy poverty, regarded as one of the sides of general poverty, fundamentally roots on the lack of financial means required to fulfill the most basic energy needs of a household jointly with other needs like food and basic services (Romero et al., 2014). It is evident that people in general poverty are often found in energy poverty as well because the little income they make, they prefer to spend on food and health rather than purchasing modern forms of energy or paying electricity bills. In the case of developed countries, people in very low income groups cannot always afford to pay their bills and keep their homes warm to a reasonable temperature. Hence the challenge of devising appropriate response options to address the modern energy needs of low income urban households remains (Bouzarovski S. , 2014). In a study done in 2015 by Phimister, Toscano & Roberts, they examine the level and dynamics of energy poverty in Spain, comparing the results to the level and dynamics of income poverty using longitudinal data and they concluded that there is a greater movement out of energy poverty at aggregate levels as compared to income poverty (Phimister et al., 2015).

- High energy prices

High energy prices can be in terms of the price of fossils, electricity, natural gas, LPG, etc. Households using modern energy sources do not only spend on purchasing these fuels but also in acquiring energy appliances. An increase in energy prices forces a lot of households to switch to cheaper forms which in most cases are traditional forms of energy. Moreover, in developed countries, people are faced with living in cold homes because they want to avoid the payment of high electricity bills. Others faces the consequences of repeated unpaid electricity bills which is power cuts by the electric utilities. Default of payment of electricity bills may cause liquidity problems for the energy service companies. Dagoumas and Kitsios (2014) in a study carried out in Greece, depicting that power cuts are mainly related to empty shops, offices and apartments and to second homes which customers do not desire to pay electricity for them given that these structures do not provide revenue for them.

- Low energy efficient buildings

According to Phimister et al. (2015), self-reported energy poverty is mostly associated with low energy efficient housing. This factor applies mainly to countries experiencing very cold weather conditions and require heating to keep their homes in favorable temperatures and comfort. Many studies have underlined that energy inefficient buildings and heating systems are the most significant components of fuel poverty by laying emphasis on older buildings in this fuel poor countries as the majority of those now documented as hard to heat. Most of this buildings are poorly insulated with poor airtightness, have leakages and with poor building envelopes requiring a considerable large level of heating to provide comfort. This also causes health effects and is also a propeller of increase winter deaths as witnessed in the UK (see Rudge, 2012). . In developing countries, people living in clustered environments and poorly constructed houses do not have access to natural day light inside their homes thereby required to use a source for lighting throughout the day instead of maximizing natural light from the sun before nightfall. This leads to increase expenditure on energy be it electricity bills, kerosene for local lamps, fuel for generators etc. which may also be a driving force to increase pollution leading to health problems and eventually death.

- Remote populations

Even though the levels of lack of electricity access might decrease when populations living in the countryside move to electrified cities, in many rural zones across the world a large number of people continue to rely on traditional forms of energy. In a number of cases those populations are located far from the grid offering centralized supplies of electricity, but also, they are far from modern-fuel suppliers. This factors influences them to make use of any energy carrier "at hand"- firewood, animal wastes, agricultural wastes, etc. The size of the rural population of a country reflects the rate of rural electrification and energy poverty of that country (Ong, 2015). On the same note, Bhandari and Jana (2010) pointed out that electrification in rural areas is costlier than urban areas because of geographical adversity, low population density, low purchasing power, low consumption, payment default just to name a few. This also increases the risk of investment in these areas.

- Unhealthy cook stoves

Lack of modern cook stoves and the continuous use of unhealthy cook stoves is a very important driver for energy poverty in LDC's given that only traditional biomass is burnt using this stoves, mostly in poorly ventilated indoor spaces causing pollution which impacts both human health and the environment negatively. The effects of inefficient cook stoves used varies with cooking in indoor spaces or outdoors. These inefficient stoves are three stone fire places, holes dug in the ground, concrete made fireplaces, to name a few, which are locally made or are not purchased. Cooking with traditional biomass and pollution resulting from this cooking activity are important indicators of energy poverty. Since these stoves are used frequently by households for cooking, they remain trapped in an energy poor situation.

- Inefficient Utilities

In many countries the lack of reliability of centralized energy supplies can be seen as a barrier for overcoming energy poverty, there are several reasons varying in their nature but some are more related with energy-related aspects of poverty than others. For instance, losses of electricity at the distribution stage of the value chain when people tap the lines, stealing electricity, has repercussions on the economic sustainability of a utility. Most importantly, the lack of investment on existent energy-related infrastructure (e.g for maintenance) increases the technical losses of electricity through the supply system. These factors along with lack of generation capacity to cover the demand result in continuous shortages on the provision of energy supplies ultimately make end-users disregard such services.

- Untapped renewable energy sources

When populations are scattered across vast territories the distances from the existing electric grid might be enormous and, the investments required for spreading centralized energy supplies, normally, results unaffordable for the state or not profitable for private investors. In such a scenario, the most suitable option for supplying electricity is the implementation of distributed energy systems using generation technologies located near the premises of those rural populations. The generation technologies include small-hydroelectric plants, biomass-powered generators, small geothermal power plants, solar fields, wind turbines, etc. (Pereira et al., 2009). These can be adopted according to the proper characteristics of the territories. Nevertheless, the costs of providing the electric services through distributed energy systems also result expensive and non-affordable for poor populations, given that investment in renewable energy sources often require a huge capital, a fact that left the prospective use of renewable energy untapped.

- Impact of the cost of energy on the family budget

Closely related with the latter driver, when energy markets are not able to offer adequate and affordable supplies, final users can be forced to spend significant portions of the family budget to cover the costs of energy supplies, buying fuels to operate electricity generators for instance, even though their incomes might not be so low. This depends on the types of energy carriers available and its affordability. This energy carriers can be electricity, natural gas, solid fuels, liquid fuels and bottled gas. Solid fuels are coal, coke, briquettes, firewood, charcoal, peat and the like; liquid fuels are domestic heating and lighting oils. Also placing tax burdens on electricity highly affects poor households disproportionately because they suffer increase in electricity bills and in the case where this taxes affects industries, who can pass on increase prices to customers (Bouzarovski S. , 2014). This can intend lead to prioritization of household expenditure on other needs rather than on energy services.

- Perceived investment risk

The uncertainties that emerge when evaluating investments in energy-supplying projects, for instance considering security of demand, pose difficulties for governments, international investors and for private investors when trying to fund infrastructures for centralized supplies. On the perspective of the energy suppliers, a stable demand is needed to guaranty a steady income for the utilities (Johansson, 2013). The economic sustainability of those businesses might be compromised in a probable scenario where modern energy supplies are available but the potential new users for different reasons do not shift to them rather they continue using what they have "at hand and for free."

Conclusively, the driving forces behind energy poverty which is deeply rooted in the developing countries today demonstrates how significant this problem is and why considerable efforts are warranted to tackle this problem. The drivers of energy poverty for both developed and developing countries aid in enabling this vice therefore policies towards eradicating energy poverty have to be geared towards eradicating these driving forces which undermine the progress made by many countries in alleviating energy poverty. A step forward to solving this problem at a national level will be to institute energy policies both on the demand and supply sides in these countries. Also, households and communities should be encouraged through publicity and training to get involved in demand side policies such as efficiency in energy use, increase use of natural day light to perform activities during the day, cooking in open spaces using efficient cooking appliances, be prosumers[7], educate and create awareness on the proper appliances to be used for energy services provision and finally, proper labeling of appliances by manufactures for identification by consumers to enable them make appropriate choices.

[7] Producing the energy you use.

CHAPTER FIVE: MEASURING THE MEPI IN SELECTED SUB-SAHARAN AFRICAN COUNTRIES

5.1 Data

The study uses household data from the MEASURE DHS (Demographic Health Survey) funded by the United States Agency for International Development (USAID). This data is a national representative data on issues such as health, fertility, family planning, malaria, nutrition, HIV/AIDS, gender and maternal and child health. It is divided in different surveys such as men survey, women survey, children survey and household survey. Based on household surveys which contains information related to indicators of energy poverty, it contains the most recent standard DHS survey data available for Sub-Saharan Africa for phase six and seven, ranging from 2010 to 2014 for these countries. Most of the data available for the 30 Sub-Saharan African countries analyzed was collected under DHS phase six (VI) with the exception of Burkina Faso (2014), Kenya (2014) and Malawi (2014) which belong to phase seven (VII). This recode data file[8] is designed to allow for consistency and comparability across surveys hence a very reliable data source suitable for analysis.

5.2 Methodology

The Multidimensional Energy Poverty Index (MEPI) derived by Nussbaumer et al. (2012) is a composite indicator that measures energy deprivation. MEPI focuses on measuring the availability of modern energy services. It takes in to account the occurrence and magnitude of energy poverty. It captures five dimensions of energy poverty centered on basic energy services, with six indicators namely cooking: type of fuel used for cooking service. Secondly, indoor pollution, considering the type of appliance used and the place where the cooking is carried out, that is if it is done in-house, in a separate building or outdoors. Another dimension captured is lighting- having access to electricity, services provided by means of household appliances which implies household appliances ownership, such as having a fridge. Moreover, it captures the entertainment/education dimension taking in to consideration household ownership of appliance

[8] A recode data file appears in a standardized format with the same structure across countries participating in each DHS phase. The recode structure utilized in this survey is that defined for households for the sixth (VI) and seventh (VII) rounds of DHS surveys

such as a radio or television. Lastly, the communication dimension, looking at households means of communication through the ownership of a mobile phone or a non-mobile phone (landline).

As seen on *Table 4* below, the indicators of this six different dimensions are assigned weights and an individual is energy poor if a combination of the deprivations faced exceeds a pre-defined threshold (Nussbaumer et al., 2012). The MEPI score is calculated as the product of a headcount ratio (share of people identified as energy poor) and the average intensity of deprivation of the energy poor. There is a total score of 1.0 and the higher the score for a country, the higher the intensity of energy poverty.

Table 4: Selected indicators and their cutoffs

Dimension	Indicator (weight)	Variable	Deprivation cut off (energy poor if…)
Cooking	Modern Cooking fuel *(0.2)*	Type of cooking fuel	any fuel use besides electricity, LPG, kerosene, natural gas, or biogas
Indoor pollution	Indoor pollution *(0.2)*	Food cooked on stove or open fire (no hood/chimney), indoor, if using any fuel beside electricity, LPG, natural gas or biogas	True
Lighting	Electricity access (0.2)	Has access to electricity	False
Services provided by means of household appliances	Household appliance ownership *(0.13)*	Has a fridge	False
Entertainment/education	Entertainment/education appliance ownership *(0.13)*	Has radio or television	False
Communication	Telecommunication means *(0.13)*	Has a landline phone or mobile phone	False

Source: Nussbaumer et al. (2012)

Formally, the MEPI measures energy poverty in *d* variables across a population of *n* individuals.

$$Y = [yij] \ldots\ldots\ldots\ldots 1$$

represents the $n \times d$ matrix of achievements for *i* persons across *j* variables.

$yij > 0$ denotes the individual *i* achievement in the variable *j*.

So, each row vector $Y = (yi1, yi2..., yid)$ represents the individual i achievements in the different variables, and each column vector $Yj = (y1j, y2j, ..., ynj)$ gives the distribution of achievements in the variable j across individuals.

The methodology is flexible enough allowing weighting of indicators unevenly if preferred. A weighting vector *w* is composed of the elements w_j corresponding to the weight that is applied to the variable *j*. We define

$$\sum_{j=1}^{d} wj \text{........... } 2$$

For the sensitivity analysis, and by means of capturing some of the uncertainty associated with assigning weights, we have applied probabilistic functions to the respective weights. We define the functions by using the deterministic weights shown in (*Table 4*).

We define z_j as the deprivation cut-off in variable *j*, and then identify all individuals deprived in any variables.

$$\text{Let } g = [\text{gij}] \text{ .... } 3$$

be the deprivation matrix whose typical element g_{ij} is defined by

$\text{gij} = \text{wj}$ when $\text{yij} < \text{zj}$ and $\text{gij} = 0$ when $yij \geq \text{zj}$

In the case of the MEPI, the element of the achievement matrix being strictly non-numeric in nature, the cut-off is defined as a set of conditions to be met **(see** *Table 4*). The entry ij of the matrix is equivalent to the variable weight w_j when a person i is deprived in variable j, and zero when the person is not deprived. Following this, we construct a column vector c of deprivation counts, where the *i*th entry

$$ci = \sum_{j=1}^{d} gij \text{ .... } 4$$

represents the sum of weighted deprivations suffered by person *i*.

By defining a cut-off $K > 0$ and applying it across the column vector we identify a person who is multidimensionally energy poor. A person is considered as energy poor if her weighted deprivation count c_i exceed *k*. Therefore, *ci (k)* is set to zero when $ci \leq k$ and equals *ci* when $ci > k$. Thus,

c (k) represents the censored vector of deprivation counts, and it is different to c in that it counts zero deprivation for those not identified as multidimensionally energy poor.

Lastly, we compute the headcount ratio H, which represents the proportion of people that are considered energy poor by including the number of people per household using data available from the survey and also the sampling weights. With q as the number of energy poor people where $ci > k$ and n the total, we have

$$H = q / n, \ldots\ldots\ldots\ldots 5$$

which represents the incidence of multidimensional energy poverty.

The average of the censored weighted deprivation counts $c_i(k)$ represents the intensity of multidimensional energy poverty A. Therefore, we compute

$$A = \sum_{i=1}^{n} ci(k)/q \ldots\ldots\ldots 6$$

The MEPI captures information on both the incidence and the intensity of energy poverty, and is defined as MEPI equals (5) x (6)

$$MEPI = H \times A^{9} \ldots\ldots\ldots\ldots 7$$

Awan et al. (2014), states that this method has the advantage of being easily comprehensible and estimable and this can be applied using ordinal data.

5.3 RESULTS AND DISCUSSION

Considering the data available, I calculated the MEPI for Sub-Saharan African countries from DHS datasets survey phase VI or VII, setting the multidimensional energy poverty cut-off at 0.3 meaning that a person is energy poor if he does not benefit from energy services supplied by electricity or has no access to clean cooking fuel. *Table 5* below shows the results obtained for the different country surveys including the years of which the survey was carried out, it demonstrates the Head count ratio, intensity of energy poverty and MEPI. It also shows the electrification rate and access to modern cooking fuel[10]**.** The countries highlighted in a darker shade demonstrates the Sub-Sahara African countries for which data was not available for the DHS phase IV and V. New data has not been made available for Lesotho and Swaziland since the 2009 and 2006-2007 data respectively for these countries.

[9] The tool used for this analysis is the STATA 13 software program.

[10] (IEA, WEO, 2015)

Table 5: Results from Data analysis at K=0.3

COUNTRY	Year of most recent DHS survey	Headcount ratio (H)	Intensity of energy poverty (A)	MEPI, K=0.3	Electricity access (%)	Modern cooking fuel access (%)
ANGOLA	2011	0.64	0.83	0.53	30	46
BENIN	2011/2012	0.95	0.73	0.7	29	6
BURKINA FASO	2014	0.95	0.75	0.71	17	5
BURUNDI	2012	1	0.85	0.85	5	2
CAMEROON	2011	0.84	0.73	0.61	55	22
COMOROS	2012	0.82	0.66	0.54	69	26
CONGO BRAZZAVILLE	2011/2012	0.79	0.71	0.56	42	26
CONGO DEMOCRATIC REPUBLIC	2013/2014	0.98	0.84	0.83	9	5
COTE D'IVOIRE	2011/2012	0.86	0.69	0.59	26	19
ETHOPIA	2011	0.98	0.87	0.86	24	5
GABON	2012	0.19	0.67	0.13	89	80
GAMBIA	2013	0.99	0.65	0.65	36	5
GHANA	2014	0.79	0.62	0.49	72	17
GUINEA	2012	0.99	0.75	0.75	26	2
KENYA	2014	0.86	0.75	0.65	20	16
LIBERIA	2013	0.99	0.79	0.8	10	2
MADAGASCA R	2013	0.99	0.86	0.87	15	2
MALAWI	2014	0.98	0.86	0.82	9	3
MALI	2012/2013	0.99	0.73	0.73	26	2
MOZAMBIQUE	2011	0.96	0.82	0.97	39	4
NAMIBIA	2013	0.66	0.71	0.47	32	46
NIGER	2012	0.99	0.81	0.81	15	3
NIGERIA	2013	0.80	0.70	0.56	45	30
RWANDA	2013	0.99	0.79	0.8	21	2
SENEGAL	2010/2011	0.72	0.67	0.49	55	39
SIERRA LEONE	2013	0.99	0.80	0.8	5	2
TANZANIA	2011/2012	0.99	0.79	0.78	24	4
TOGO	2013/2014	0.95	0.73	0.69	27	5
ZAMBIA	2013/2014	0.89	0.77	0.69	26	18
ZIMBABWE	2010/2011	0.74	0.85	0.63	40	29

The map below (Fig 5) represents MEPI results for selected Sub Saharan African countries is shaded in different colors to distinguish the degree or level of energy poverty. These ranges from acute poverty (> 0.8) namely, Niger, Ethiopia, Madagascar, Malawi, Democratic Republic of Congo and Liberia, to countries in moderate poverty (<0.5) namely Namibia, Angola, Gabon, Cote D'Ivoire and Senegal.

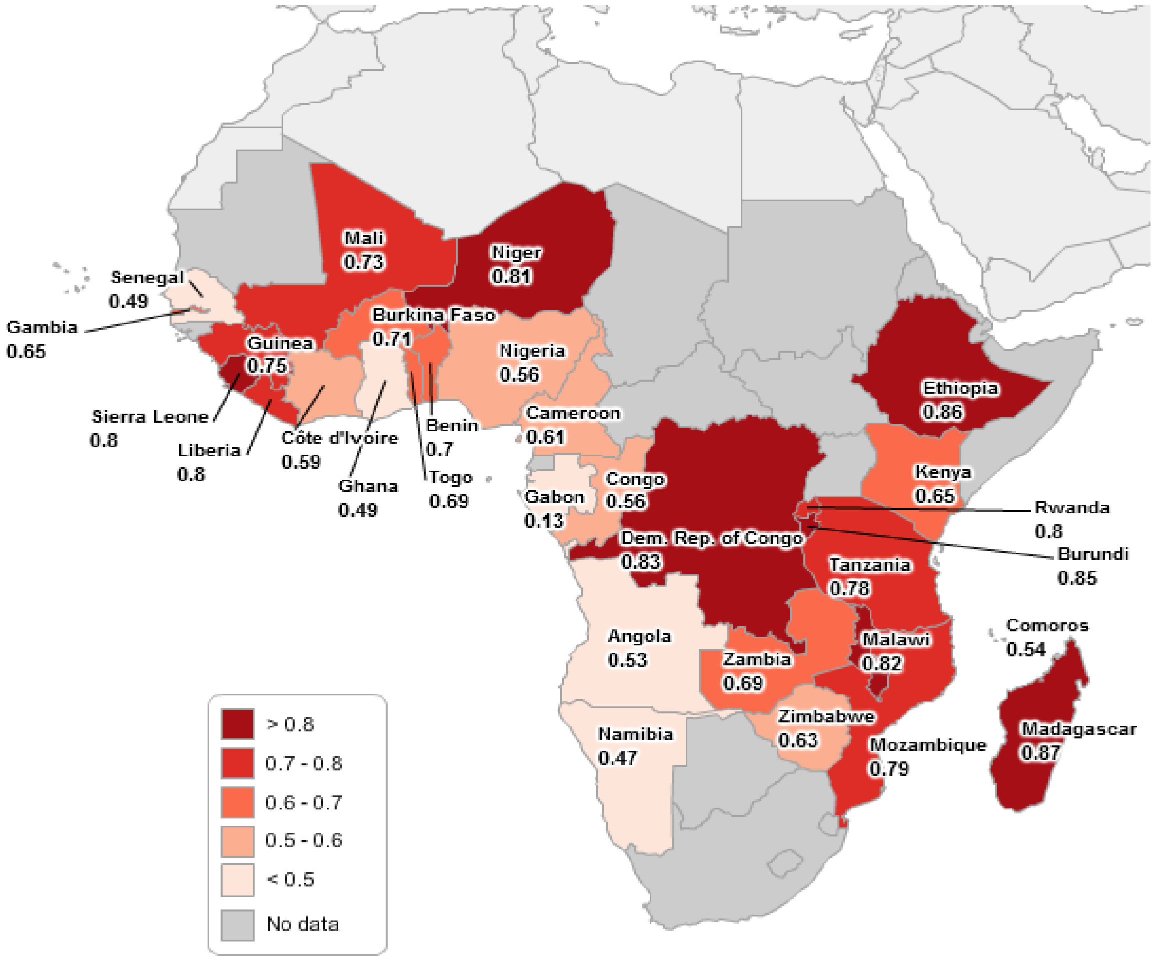


Figure 5: Visual representation of MEPI for selected Sub-Saharan countries

(Visual created using statplanet)

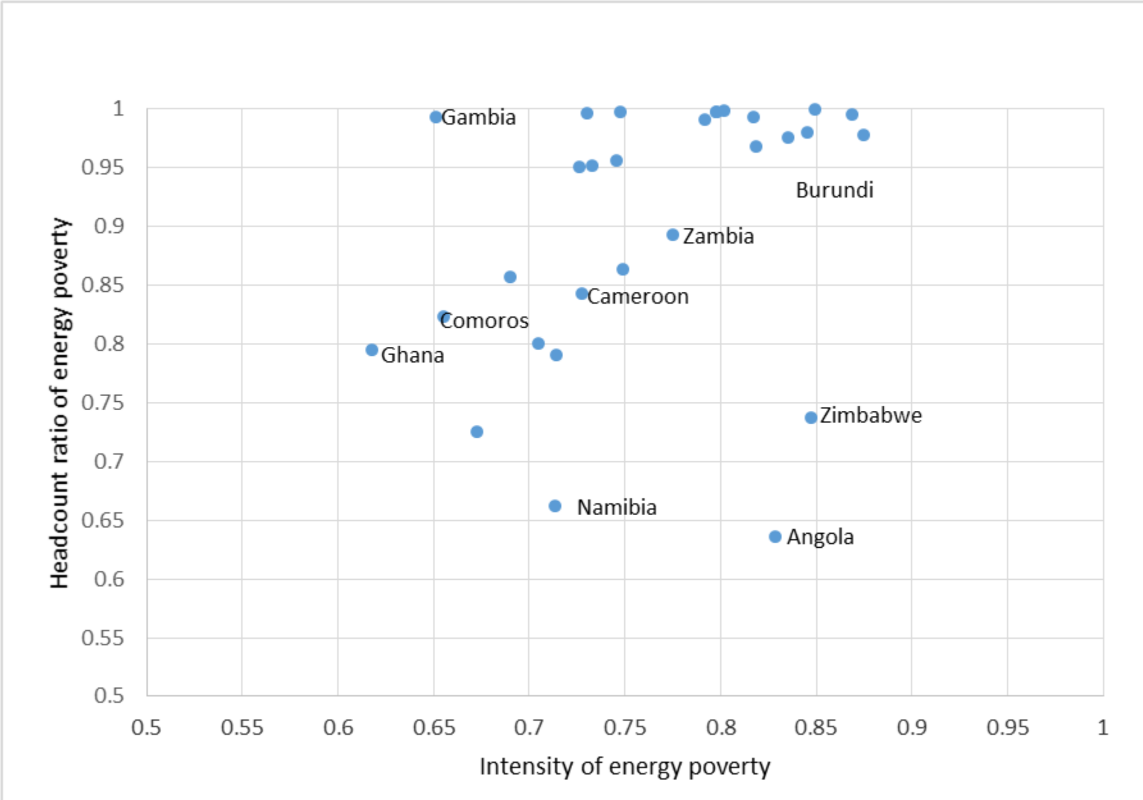


Figure 6: Headcount ratio vs intensity of energy poverty

Figure 6 above represents the headcount ratio plotted against the intensity of energy poverty. Setting an imaginary trend line, this demonstrates that for countries appearing above this trend line, the intensity of energy poverty is significantly lower as compared to the headcount ratio of the poor and vice versa for countries below this line. Judging from the graph, Namibia and Ghana has an MEPI which is comparable but the ratio of people experiencing energy poverty is higher in Ghana whereas the intensity of energy poverty is greater in Namibia. The same holds true for Comoros and Angola as well as Zimbabwe and Gambia.

From another dimension, the intensity of poverty is almost identical for Zimbabwe and Burundi. Nonetheless, in relative terms, there are more energy poor people in Burundi than in Zimbabwe.

5.4 TRENDS IN MEPI

Here we look at the evolution of MEPI over time based on comparison between data from DHS surveys of phase five and six. This analysis utilizes the results obtained by Nusbaumer et al. (2011) and compares it with that of similar countries with the most recent data available under DHS phase six (VI) dataset. One exception has been made for Mozambique since data used in Nusbaumer et al. (2011) happens to be for phase four (V) DHS survey but data for phase five (V) is currently available hence I analyzed the data for the sake of assessment in this thesis. The results obtained are demonstrated on the graph below.

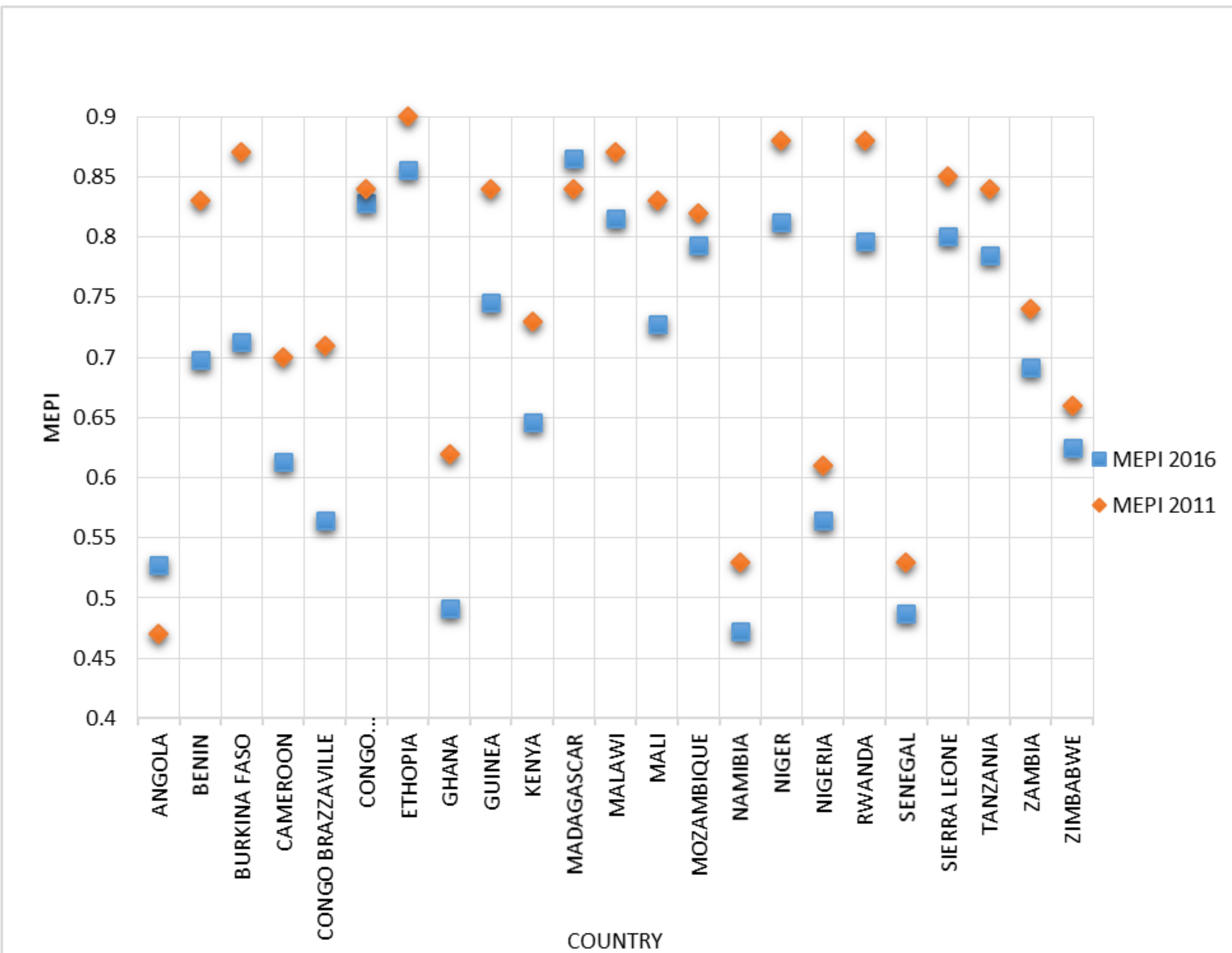


Figure 7: Trends in MEPI

On the graph above, all countries have showed a reduction in the level of energy poverty with the exceptions of Angola and Madagascar which demonstrates that the trends have worsen by an increase in MEPI from phase V to phase VI. Also the difference in MEPI for the two datasets is greater for Burkina Faso, Congo Brazzaville, Benin and Ghana chronologically than for the other countries.

Sub Saharan Africa is naturally endowed with a lot of resources which if exploited will adequately supply the energy needs of the massive growing population. For example sustainably extracted agricultural and forestry residues could supply close to 40% of Cameroon's electricity consumption without causing deforestation (IEA, 2014). Some of the countries, Benin, Burkina Faso and Niger depend on imports for a significant share of their energy supply whereas a country such as Nigeria rich in oil and gas capacities still suffers huge under capacity in electricity generation with frequent power cuts driving consumers to expensive backup power generations. The high share of fossil fuels in its energy mix results to a relatively high average cost of generation as well leading to high electricity prices (IEA, 2014).

Taking a closer look at the energy situation in Angola from 2011, the country has faced massive development challenges such as a reduction in the dependency of oil due to the decline of international crude oil price impacting budget balances leading to delay of key electricity and industrial developments (WORLD BANK, 2016). The country also faces a substantial growth of about 25% per year in electricity consumption with its generation principally from hydropower (4251GWh) and oil (1744GWh) (OECD/IEA). Despite its enormous natural resources, only 4% capacity of hydropower in Angola is being tapped (IEA, 2014). With 30% national electrification and 18% rural electrification rate, and very frequent power outages, households depend on relative grid supply, backup power generations which is expensive and levels of use are generally not recorded in energy statistics (IEA, 2014).

In the same light, Madagascar has 98% dependence on biomass for cooking and heating, 15% national electrification rate and 4% rural electrification rate in 2013 (IEA/WEO, 2015). The energy balances of this country shows that about 80% of overall consumption is based on biomass with 68% from firewood, 10% from charcoal and 2% from other biomass. For electricity, 2% is generated from hydropower and diesel and 1% from coal and all petroleum fuels are gotten from imports. Madagascar has oil fields which are not yet exploited (MINISTERE DE L'ENERGIE, n.d). Currently the utilized capacity of hydropower is even lower due to poor efficiency following the lack of rehabilitation of some of the previously existing power plants (IEA, 2014). Aside from the capital, most of the electrified cities and villages depend on isolated small and mini grids and the use of kerosene and candles for lighting homes (Energypedia, 2016). This and many other factors have contributed to an increase in MEPI of Angola and Madagascar.

Many other countries as shown on the graph has fairly reduced their MEPI in comparison from previous analysis. This has been achieved through increase in renewable energy deployment, creation of new supply sources through investments and new natural resources discovered.

5.5 SENSITIVITY ANALYSIS

The sensitivity analysis carried out in this study is to demonstrate that a change in cut-off point k does not significantly affect the results of MEPI derived. Table 6 below demonstrates the results of MEPI obtained when the cutoff level K is changed from 0.2, 0.25, 0.3, 0.35, to 0.4.

Table 6: Effects of multidimensional energy poverty deprivation cut-off change on the MEPI

COUNTRY	MEPI at K=0.2	MEPI at K=0.25	MEPI at K=0.3	MEPI at K=0.35	MEPI at K=0.4
ANGOLA	0.53	0.53	0.53	0.51	0.51
BENIN	0.7	0.68	0.7	0.7	0.7
BURKINA FASO	0.71	0.71	0.71	0.71	0.71
BURUNDI	0.85	0.85	0.85	0.85	0.85
CAMEROON	0.62	0.62	0.61	0.61	0.61
COMOROS	0.54	0.54	0.54	0.54	0.54
CONGO BRAZZAVILLE	0.57	0.57	0.56	0.55	0.55
CONGO DEMOCRATIC REPUBLIC	0.83	0.83	0.83	0.83	0.83
COTE D'IVOIRE	0.59	0.59	0.59	0.59	0.59
ETHOPIA	0.86	0.86	0.86	0.86	0.86
GABON	0.13	0.13	0.13	0.12	0.12
GAMBIA	0.65	0.65	0.65	0.65	0.65
GHANA	0.49	0.49	0.49	0.49	0.49
GUINEA	0.75	0.75	0.75	0.75	0.75
KENYA	0.65	0.65	0.65	0.64	0.64
LIBERIA	08	0.8	0.8	0.77	0.8
MADAGASCAR	0.87	0.87	0.87	0.87	0.87
MALAWI	0.82	0.82	0.82	0.82	0.82
MALI	0.73	0.73	0.73	0.73	0.73
MOZAMBIQUE	0.79	0.79	0.79	0.79	0.79
NAMIBIA	0.47	0.47	0.47	0.46	0.46
NIGER	0.81	0.81	0.81	0.81	0.81
NIGERIA	0.57	0.57	0.56	0.56	0.56
RWANDA	0.8	0.8	0.8	0.8	0.8
SENEGAL	0.49	0.49	0.49	0.49	0.49
SIERRA LEONE	0.8	0.8	0.8	0.8	0.8
TANZANIA	0.79	0.78	0.78	0.78	0.78
TOGO	0.69	0.69	0.69	0.69	0.69
ZAMBIA	0.69	0.69	0.69	0.69	0.69
ZIMBABWE	0.63	0.63	0.63	0.62	0.62

This effect of change in cutoff level is graphically represented below.

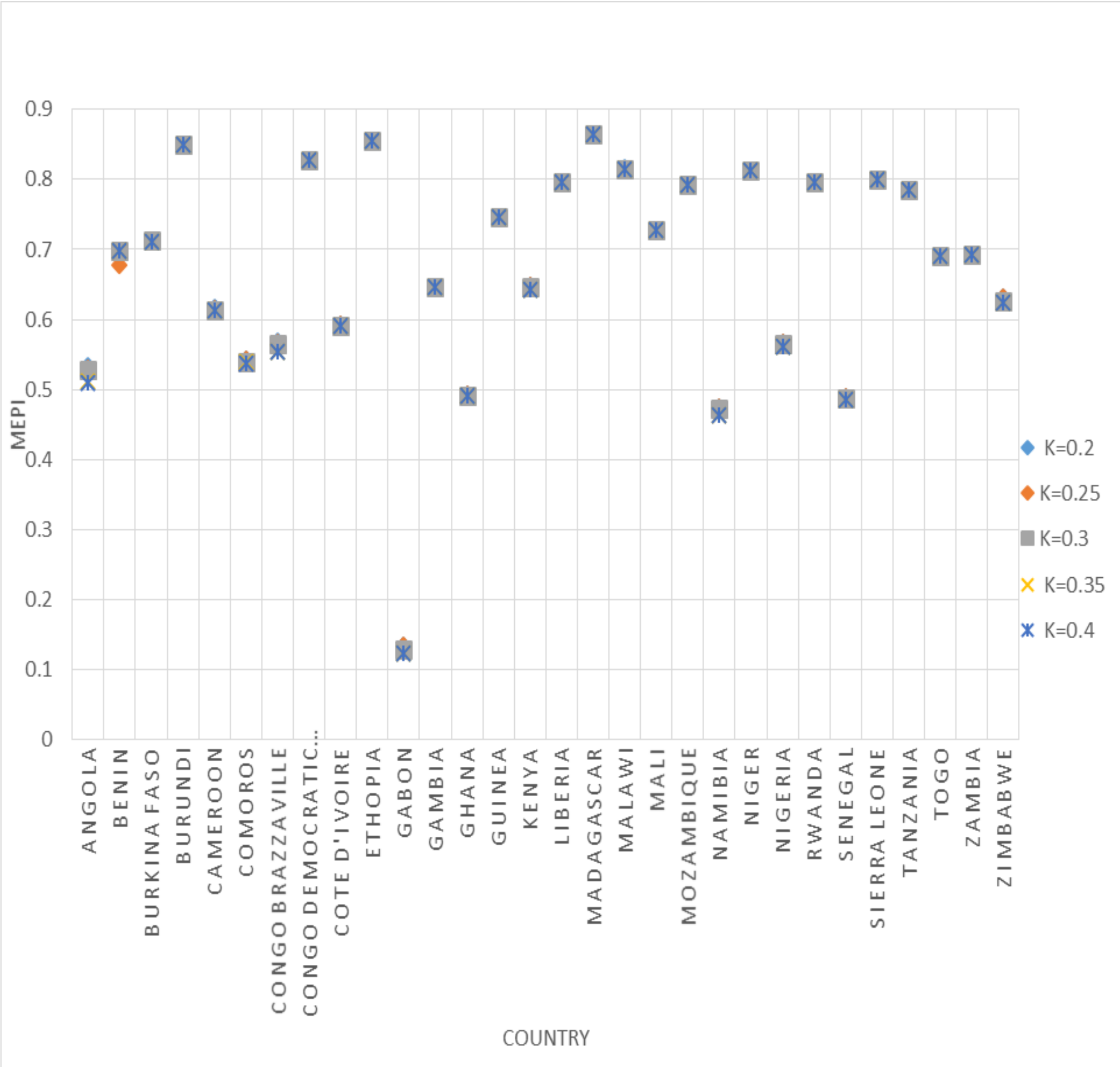


Figure 8: Effects of cut off change on country's MEPI

Figure 8 above represents the energy poverty cut-off change in absolute terms. By varying the multidimensional energy poverty cut-off, K, from 0.2 to 0.4, as seen on the table above, the results show that the change in the cut-off does not have any significant impact on MEPI. We notice that for each country the points from 0.2 to 0.4 cut-off values does not show any discrepancy as plotted in the graph. Hence altering the cut-off the pattern clearly remains the same.

CHAPTER SIX: CONCLUSIONS

This research has made a critical review on energy poverty from different perspectives, the current situation and future outlook and a synthesis of studies carried out on energy poverty and fuel poverty. I went a step further to examine the drivers behind energy poverty and reasons why despite the detrimental effects of these drivers to any society, they have not been eradicated to preclude their influence in propelling this problem. With a number as high as 1.2 billion people worldwide not having access to electricity and 2.7 billion people still depending on biomass for cooking, with a majority of these population living in Sub Saharan Africa, it already establishes a fact that the world's energy poor are concentrated in these area. These makes household's liable to other social, economic and environmental ills associated to energy poverty affecting their daily lives.

Furthermore, the drivers of energy poverty suggest that energy poverty is deep rooted in Sub Saharan Africa. The most prominent drivers which exist in both developed and developing countries includes low household income, high energy prices and low energy efficient buildings. These drivers among others must be tackled for progress on eliminating energy poverty to be achieved. In this case, a lot must be done at national levels with the collaboration of governments and households to solve this problem.

Moreover, in literature a lot of analysis have been done using different methodologies to calculate energy poverty using several case studies. All these studies have shown that energy poverty exist in these countries which has been confirmed by the analysis carried out in this study. Using the MEPI methodology, designed to capture and evaluate a set of energy deprivations that affects a person or household with the availability of recent data from MEASURE DHS, I have extended this study analysis. The results obtained from this analysis includes a detail examination of the headcount ratio (H), intensity of energy poverty (A) and the MEPI of selected Sub Saharan African countries based on selected indicators and cutoffs. We also look at the evolution of energy poverty over time making use of results from a previous study by Nussbaumer et al. (2012). Comparing the results achieved from both studies, the trends demonstrate a reduction in energy poverty for 21 out of the 23 analyzed countries. This shows that the fight against energy poverty through energy access programs, energy efficiency the deployment of clean energy among others is yielding fruits in these countries especially in Burkina Faso, Congo Brazzaville, Benin and Ghana which demonstrate a very high difference in MEPI from previous analysis. In the case of Angola and Madagascar, where the trends have rather regressed, lessons can be learnt from the remaining countries, which have a lot of similarities in terms of primary energy resources. For example only 4% and 2% of hydropower capacity for Angola and Madagascar respectively is being tapped for electricity production. Other energy sources still remain unexploited while most of the exploited resources are exported abroad.

Governments and policy makers in energy poor nations should not rely completely on the supply sources which are available at the moment but they should also make substantial investments in rehabilitating and revitalizing these sources to maximize its capacity. They should also ensure that energy generation and transmission appliances are fully exploited. Governments have to ensure that some of these exploited resources are used internally to increase availability of electricity, which also promotes growth and development in these countries rather than traded to foreign countries.

Finally, energy poverty still occurs in Sub Saharan Africa but at a reduced rate and it is evident that these rates will reduce further as more is being done to alleviate general poverty. Even at the current level of resources available for the provision of energy services and the implementation of efficient policies such as labeling, efficiency in energy use, use of natural sunlight for daytime lighting, efficient production of charcoal which produces less pollution as compared to burning wood, fuel switching and community involvement in energy access programs.

BIBLIOGRAPHY

Alhborg, H., Boräng, F., Jagers, S. C., & Söderholm, P. (2015). Provision of electricity to African households: The importance of democracy and institutional quality. *Energy Policy, 87*(125), 125-135.

Barnes, D. F., Khandker, S. R., & Samad, H. A. (2011). Energy poverty in rural Banglasdesh. *Energy policy, 39*(2), 894-904.

Bazilian, M., Nakhooda, S., & Van De Graaf, T. (2014). Energy governance and poverty. *Energy Research & Social Science, 1*(January), 217–225.

Bazilian, M., Nussbaumer, P., Rogner, H.-h., Brew-hammond, A., Foster, V., Pachauri, S., . . . Kammen, D. M. (2012). Energy access scenarios to 2030 for the power sector in sub-Saharan Africa. *Utilities Policy, 20*(1), 1-5.

Bazilian, M., Sagar, A., Detchon, R., & Yumkella, K. (2010). More heat and light. *Energy Policy, 38*(10), 5409-5412.

Berger, T. (2012, May , Bregenz, Austria 2-4). Energy poverty – from a global perspective to Austria. *15th European Roundtable on Sustainable Consumption and Production* (pp. 1-8). Bregenz, Austria: Inter-University Research Centre for Technology, Work and Culture (IFZ).

Bhandari, A. k., & Jana, C. (2010). A comparative evaluation of household preferences for solar photovoltaic standalone and mini-grid system: An empirical study in a costal village of Indian Sundarban. *Renewable Energy, 35*, 2835-2838.

Bhattacharyya, S. C. (2011). ENERGY ECONOMICS. concepts, issues, markets and governance. London Dordrecht Heidelberg New York: Springer.

Bhide, A., & Monroy, C. R. (2011). Energy poverty: A special focus on energy poverty in India and renewable energy technologies. *Renewable and Sustainable Energy Reviews, 15*(2), 1057-1066.

Birol, F. (2007). Energy economics: a place for energy poverty in the agenda? *The energy Journal, 28*(3), 1-6.

Boardman, B. (2004). New directions for household energy efficiency: evidence fromthe UK. *Energy Policy 32, 32*(17), 1921-1933.

Bouzarovski, S. (2014). Social justice and climate change: Addressing energy poverty at the European scale. *Spring Alliance initiative 'Tax justice and climate change' , supported by the King Baudouin Foundation,*, pp. 1-6.

Bouzarovski, S., & Petrova, S. (2015). A global perspective on domestic energy deprivation: Overcoming the energy poverty–fuel poverty binary. *Energy Research & Social Science, 10,*, 31–40.

Bouzarovski, S., Herrero, S. T., Petrova, S., & Ürge-, D. (2015). Unpacking the spaces and politics of energy poverty: path-dependencies, deprivation and fuel switching in post-communist Hungary. *The International Journal of Justice and Sustainability, 9839,* 1-16.

BPIE. (2014). *Alleviating fuel poverty in the EU: INVESTING IN HOME RENOVATION, A SUSTAINABLE AND INCLUSIVE SOLUTION.* Buildings Performance Institute Europe (BPIE).

Chard, R., & Walker, G. (2016). Living with fuel poverty in older age: Coping strategies and their problematic implications. *Energy Research & Social Science*, 1-7.

Clinch, P., & Healy, J. (2001). Cost-benefit analysis of domestic energy efficiency. *Energy Policy, 29*, 113-124.

Dagoumas, A., & Kitsios, F. (2014). Assessing the impact of the economic crisison energy poverty in Greece. *Sustainable Cities and Society, 13,* 267-278.

Energypedia. (2016). Retrieved from Madagascar Energy Situation: https://energypedia.info/wiki/Madagascar_Energy_Situation#Energy_Demand_and_Supply_in_the_Household_Sector. Accessed on March 08, 2016.

EPEE. (n.d). *European fuel poverty and energy efficiency.* France: Intelligent efficiency Europe. Retrieved from EPEE, http://www.fuel-poverty.eu.

Gómez-Paredes, J., Yamasua, E., Okumura, H., & Ishihara, K. N. (2013). Energy efficiency to reduce poverty and emissions: a silver bullet or wishful thinking? Analysis of efficient lighting. *Procedia Environmental Sciences, 17*, 547–556.

González-Eguino, M. (2015, July). Energy poverty: An overview. *Renewable and sustainable enrgy reviews, 47*, 377-385.

Grevisse, F., & Brynart, M. (2011). Energy poverty in Europe: Towards a more global understanding. *ECEEE 2011 SUMMER STUDY • Energy efficiency first : The foundation of a low-carbon society*, pg 545.

Guruswamy, L. (2016). *Interational Energy and Poverty. the emerging contours.* New York: Routledge.

Hák, T., Janouˇsková, S., & Moldan, B. (2016). Sustainable Development Goals: A need for relevant indicators. *Ecological Indicators, 60*, 565–573.

Hills, J. (2011). *Fuel poverty: the problem and its measurement.* London, UK.: CASE report, 69. Department for Energy and Climate Change,.

Horst, G. H.-v., & Ã, A. J. (2008). Reassessing the ‘‘energy ladder’’: Household energy use in Maun, Botswana. *Energy Policy 36*, 3333-3344.

Iddrisu, I., & Bhattacharyya, S. C. (2015). Sustainable EnergyDevelopmentIndex:Amulti-dimensionalindicator. *Renewable and Sustainable Energy Reviews 50 (2015), 50*, 513–530.

IEA. (2014). *Africa Energy Outlook: A FOCUS ON ENERGY PROSPECTS IN SUB-SAHARAN AFRICA.* Paris, fRANCE: INTERNATIONAL ENERGY AGENCY.

IEA. (March 2010). *Comperative study on electrification studies in emerging economies: Key to successful policies.* France: IEA.

IEA, UNDP, UNIDO. (2010). *Energy poverty, How to make modern energy access universal?* Paris, France: IEA,OECD. Retrieved from http://www.worldenergyoutlook.org/docs/weo2010/weo2010 poverty.pdf.

IEA, WEO. (2015). *Energy accses database.* http://www.worldenergyoutlook.org/resources/energydevelopment/energyaccessdatabase/ : IEA, World Energy Outlook.

Johansson, B. (2013, November 1). Security aspects of future renewable energy systems–A short overview. *Energy, Volume 61*, Pages 598–605.

Kaygusuz, K. (2011). Energy services and energy poverty for sustainable rural development. *Renewable and Sustainable Energy Reviews 15*(2), 936–947.

Lawson, R., Williams, J., & Wooliscroft, B. (2015). Contrasting approaches to fuel poverty in New Zealand. *Energy Policy, 81*, 38–42.

Legendre, B., & Ricci, O. (2015). Measuring fuel poverty in France: Which households are the most fuel vulnerable? *Energy Economics, 49*, 620–628.

Liddell, C., Morris, C., McKenzie, S. J., & Rae, G. (2012). Measuring and monitoring fuel poverty in the UK: National and regional perspectives. *49*(Special Section: Fuel Poverty Comes of Age: Commemorating 21 Years of Research and Policy), 27-32.

Mayer, I., & Dubois, U. (2009). Energy poverty in France and Germany: Perceptions and policy approaches. 1-3.

Mayer, I., Nimal, E., Nogue, P., & Sevenet, M. (2014). The two faces of energy poverty: A case study of households’ energy burden in the residential and mobility sectors at the city level. *Transportation Research Procedia, 4,* 228 – 240.

MINISTERE DE L’ENERGIE. (n.d). *MADAGASCAR: Expression of Interest to participate in the Scaling Up Renewable Energy In Low Income Countries Program (SREP).* MINISTERE DE L’ENERGIE.

Modi, V., McDade, S., Lallement, D., & Saghir, J. (2005). *Energy Services for the Millenium Development Goals.* USA: Energy Sector Management, United Nations Development Programme, U N Millennium Project.

Moore, R. (2012). Definitions of fuel poverty: Implications for policy. *Energy policy*, 1-7.

Nlom, J. H., & Karimov, A. A. (2015). Modeling Fuel Choice among Households in Northern Cameroon. *Sustainability*, 9989-9999.

Nussbaumer, P., Bazilian, M., & Modi, V. (2012). Measuring Energy Poverty: Focusing on What Matters. *Renewable and Sustainable Energy Reviews, 16*(1), 231-243.

Nussbaumer, P., Bazilian, M., & Patt, A. (2013). A statistical analysis of the link between energy and the Millennium Development Goals. *Climate and Development, 5*(2), 101-112.

Nussbaumer, P., Nerini, F. F., Onyeji, I., & Howells, M. (2013). Global Insights Based on the Multidimensional Energy Poverty Index (MEPI). *Sustainability, 5*(5), 2060-2076;.

OECD/IEA. (2016). *ANGOLA: Electricity and Heat 2013*. Retrieved from International E nergy Agency (IEA): https://www.iea.org/statistics/statisticssearch/report/?year=2013&country=Angola&product=ElectricityandHeat. Accessed on May 23, 2016.

Ong, C. (2015). Choice of Energy Paths: Its Implications for Rural Energy Poverty in Less Developed Countries. *Society & Natural Resources, 28*, 733–748.

Pachauri, S., & Spreng, D. (2003). Energy use and energy access in relation to poverty. *Economic and political weekly*(25), 1-13.

Pachauri, S., Mueller, A., Kemmler, A., & Spreng, D. (2004). On Measuring Energy Poverty in Indian Households. *World Development, 32*(12), 2083-2104.

Panos, E., Densing, M., & Volkart, K. (2015). Access to electricity in the World Energy Council's global energy scenarios: An outlook for developing regions until 2030. *Energy Strategy Reviews, 9*, 28-49.

Pereira, M. G., Fidelis da Silva, N., & Aure´ lio Vasconcelos Freitas, M. (2011). The challenge of energy poverty: Brazilian case study. *Energy Policy, 39*, 167-175.

Pereira, M. G., Freitas, M. A., & da Silva, N. F. (2009). Rural electrification and energy poverty: Empirical evidences from Brazil. *Renewable and Sustainable Energy Reviews, 14*(4), 1229–1240.

Phimister, E., Vera-Toscano, E., & Roberts, D. (2015). The dynamics of energy poverty: Evidence form spain. *Economics of Energy & Environmental Policy, 4*(1), 153-165.

Reddy, A. (2000). Energy and social issues. In K. B. W Annecke, *Energy and the challange of sustainability* (pp. 1-447). New York: UNDP.

Reddy, B. (2015). Access to modern energy services: An economic and policy framework. *Renewable and Sustainable Energy Reviews , 47*, 198–212.

Roberts, D., Vera-Toscano, E., & Phimister, E. (2015). Energy poverty in the UK: Is there a difference between rural and urban areas? *Paper presented at the 89th Annual Conference of the Agricultural Economics Society*, (pp. 1-13). Warwick University,.

Romero, J. C., Linares, P., Otero, X. L., Labandeira, X., & Alonso, A. P. (2014). *Pobreza Energética en España. Análisis económico y propuestas de actuación.* Informe 2014. Retrieved from http://eforenergy.org/actividades/Presentacion-del-Informe-Anual-de-2014-de-Economics-for-Energy-Pobreza-Energetica-en-Espana-Analisis-Economico-y-Propuestas-de-Actuacion.php

Rudge, J. (2012). Coal fires, fresh air and the hardy British: A historical view of domestic energy efficiency and thermal comfort in Britain. *Energy Policy, 49*, 6–11.

Ruiz-Mercado, I., Masera, O., Zamora, H., & Smith, K. R. (2011). Adoption and sustained use of improved cookstoves. *Energy Policy, 39*(12), 7557–7566.

Ryan, w., Liddle, C., McKenzie, P., Morris, C., & Lagdon, S. (2014). Fuel poverty in Northern Ireland: Humanizing the plight of vulnerable households. *Energy Research & Social Science, 4*(c), 89–99.

Scarpellini, S., Rivera-Torres, P., Suárez-Perales, I., & Aranda-Usón, A. (2015). Analysis of energy poverty intensity from the perspective of the regional administration: Empirical evidence from households in southern Europe. *Energy Policy , 86*, 729-738.

Schuessler, R. (2014). Energy Poverty Indicators: Conceptual Issues Part I: The Ten-Percent-Rule and Double Median/Mean Indicators. *ZEW*(Discussion Paper No. 14-037). Retrieved from http://ftp.zew.de/pub/zew-docs/dp/dp14037.pdf

Schweizer-Ries. (2009). *Energy poverty: Impact and Public Recognition in the United Kingdom, France, Germany, Italy and Poland.* Project report within the scope of FinSH 'Financial and Support Instruments for Fuel Poverty in Social Housing' www.finsh.eu.

Serwaa Mensah, G., Kemausuor, F., & Brew-Hammond, A. (2013). Energy access indicators and trends in Ghana. *Renewable and Sustainable Energy Reviews, 30*, 317-323.

Sher, F., Abbas, A., & Awan, R. U. (2014). An Investigation of Multidimensional Energy Poverty in Pakistan:. *International Journal of Energy Economics and Policy, 4*(No 1), 65-75.

Shrimali, G., Slaski, X., Thurber, M. C., & Zerriffi, H. (2011). Improved stoves in India: A study of sustainable business models. *Energy Policy, 39*(12), 7543-7556.

Sovacool et al. (2012). What moves and works: Broadening the consideration of energy poverty. *Energy Policy, 42*, 715–719.

Sovacool, B. K. (2015). Fuel poverty, affordability, and energy justice in England: Policy. *Energy 93 (2015)*, 361- 371.

Sumiya, B. (2016). Energy Poverty in Context of Climate Change: What Are the Possible Impacts of Improved Modern Energy Access on Adaptation Capacity of Communities? *International Journal of Environmental Science and Development, 7*(1).

Teller-Elsberg, J., Sovacool, B., Smith, T., & Laine, E. (2015). Fuel poverty, excess winter deaths ,and energy costs in Vermont: Burdensome for whom? *Energy Policy 90*, 81-91.

Tombofa, S. (2013). Multidimensional Energy Poverty in the South-South Geopolitical Zone of Nigeria. *Journal of Economics and Sustainable Development, 4*(20), 96-104.

Treiber, M. U., Grimsby, L. K., & Aune, J. B. (2015). Reducing energy poverty through increasing choice of fuels and stoves in Kenya: Complementing the multiple fuel model. *Energy for Sustainable Development, 27*, 54–62.

Troncoso, K., Castillo, A., Merino, l., Lazos, E., & Masera, O. R. (2011). Understanding an improved cookstove program in rural Mexico: An analysis from the implementers'perspective. *Energy Policy, 39*(12), 7600–7608.

United Nations. (n.d.). *SUSTAINABLE DEVELOPMENT GOALS*. Retrieved March 15, 2016, from Sustainable Development Knowledge platform: https://sustainabledevelopment.un.org/

Wank, K., Wang, Y. X., Li, K., & Wei, Y. M. (2015). Energy poverty in China: An index based comprehensive evaluation. *Renewable and Sustainable Energy Reviews, 47*, 308–323.

Wishanti, D. (2015). Alleviating energy poverty as Indonesian development policy inputs post-2015: improving small and medium scale energy development. *Procedia Environmental Sciences 28, 28*(SustaiN 2014), 352-359.

WORLD BANK. (2016). *Working for a World Free of Poverty*. Retrieved from The World Bank IBRD. IDA: http://www.worldbank.org/en/country/angola/overview. April 08, 2016.

Yaw, G. (2009). *Solar PV rural electrification and energy poverty: A review and conceptual framework with reference to Ghana.* Bonn: ZEF Working Paper Series, No 36.

Zobel, G. (2013, August 13). *Alfredo Moser: Bottle light inventor proud to be poor.* Retrieved from BBC World Service, Uberaba, Brazil: http://www.bbc.com/news/magazine-23536914. Accessed on 13th March 2016.