The role of energy poverty on economic growth in sub-Saharan African countries

Singh, K., and Inglesi-Lotz, R.[1],

Department of Economics, University of Pretoria, South Africa

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Abstract

Appreciating firstly the importance of access to basic services and secondly, the lack of infrastructure particularly in the energy domain in the African continent, the aim of this paper is to examine empirically the role of energy poverty to economic growth in the sub-Saharan region. The findings aim to assist in proposing directions to policy makers for the implications of lack of access to energy as well as to relevant organisations to aid with deployment of sound policies and efforts towards well-functioning energy options. The empirical analysis is based on fixed effects panel data estimation as well as a Generalized Method of Moments (GMM) estimation including of fourteen sub-Saharan African countries (Benin, Botswana, Cameroon, Congo – Republic, Kenya, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Swaziland (Eswatini), Tanzania and Togo) for the period from 1990 to 2016. The empirical investigation found that access to electricity is a positive contributor to this group of countries' economic growth, with relatively low impact on a direct basis. This study provides evidence for the direct effect and also, raises the issue of all the health, education, income generating impact that access to electricity will provide to future generations.

Keywords: energy poverty; repeated cross-section panel data; sub-Saharan Africa; access to electricity.

[1] Corresponding author. Email: roula.inglesi-lotz@up.ac.za. Address: Tukkiewerf building, Main Campus University of Pretoria, South Africa.

Introduction

Access to energy is one of the essential inputs for socio-economic development (Johansson & Goldemberg, 2002; Davidson & Sokona, 2002). Access to energy is also one component of the wider range of problematic issues faced by those living in poverty. The Sustainable Development Goal (SDG) 7 also stresses the importance of access to clean and affordable energy for all towards ensuring future sustainability.

Poverty is conceptualized in material terms as not having access to adequate levels of food, water, clothing, shelter, sanitation, health care and education. Economic poverty is defined as the insufficient income to acquire basic goods and services; within this definition, energy poverty is defined as the exclusion of people from basic access to energy that is energy poverty. While poverty research has strong motives that describe poverty eradication as an ethical, political and economic imperative, there is serious debate on the overarching objective that set the target of halving global extreme poverty by 2015 (Cecelski, 2000; González-Eguino, 2015). This was the objective rekindled in the internationally agreed development goals of the “Millennium Development Goals” (UN, 2000) and the most recently “Sustainable Development Goals” (United Nations, 2018). In 2016, global poverty levels have changed little over the past two decades except in China and East Asia (Brew-Hammond, 2007). Within the various facets of poverty, González-Eguino (2015) mentions that the energy sector has been extensively analysed in the terms of energy security and climate change however with less analyse of energy poverty.

In addition, the particular and important role of electricity to the countries’ economic growth has been extensively discussed in the energy literature. The literature has not reached clear consensus on nexus between electricity and economic growth but Payne (2010) summarizes the four hypotheses assumed and confirmed: growth (electricity consumption economic growth); conservation hypothesis (economic growth electricity consumption); neutrality (electricity consumption ≠ economic growth); and feedback (electricity consumption ↔ economic growth).

In sub-Saharan Africa, the socio-economic dynamics of energy poverty are debated in the literature. Energy poverty is a global concern by institutions and non-profit organisations namely, Gates

Foundation, World Energy Council, World Economic Forum and World Health Organisation (IEA, 2014; IMF, 2013). The global concerns of energy poverty is the severe and fatal health impacts, substantial time to procure forms of biomass thereby increases the burden of chores to women and/or young girls and preserves gender inequality. With the urgency of addressing energy poverty coupled with the significant allocation of resources from institutions and non-profit organisations to tackle this challenge, it is under this backdrop the timing is appropriate for economic research on this topic.

Apart from the global concern in the sub-Saharan African region, it is priority for reliable and affordable energy to be widely available which is critical to the development of this region. This region is important as sub-Saharan African region accounts for 13% of the world's population, yet only 4% of its energy demand. This is evident from sub-Saharan Africa's rapid economic growth contributing to energy use rising by 45%, since 2000 (IEA, 2014).

A major objective of development policy in sub-Saharan African countries is also alleviating poverty. Ideally, alleviating poverty is to create an environment of inclusive growth which achieves an efficient allocation of resources is vital. One of the channels to reduce the population's poverty is through provision of access to energy and other services.

Hence, the primary aim of this paper is to examine empirically the role of energy poverty to boosting economic growth in the sub-Saharan African region, within the context of the importance of electricity consumption to ignite growth and development. Specifically, this paper examines the hypothesis that energy poverty is a positive contributor to economic growth in the context of developing countries with a focus on fourteen sub-Saharan African countries (Benin, Botswana, Cameroon, Congo – Republic, Kenya, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Swaziland, Tanzania and Togo.) for the period from 1990 to 2016.

The findings will have important policy implications in quantifying the effect that some change in the access to electricity will have on the growth of an economy. Policy makers need to make optimal allocation of funds in order to increase the energy infrastructure, and hence, they are interested in the economic benefits of such investments. This research is also relevant given that many sub-Saharan

African countries are in a unique position of shifting investments in the energy sector as traditional forms of energy production are being replaced by modern sustainable energy options.

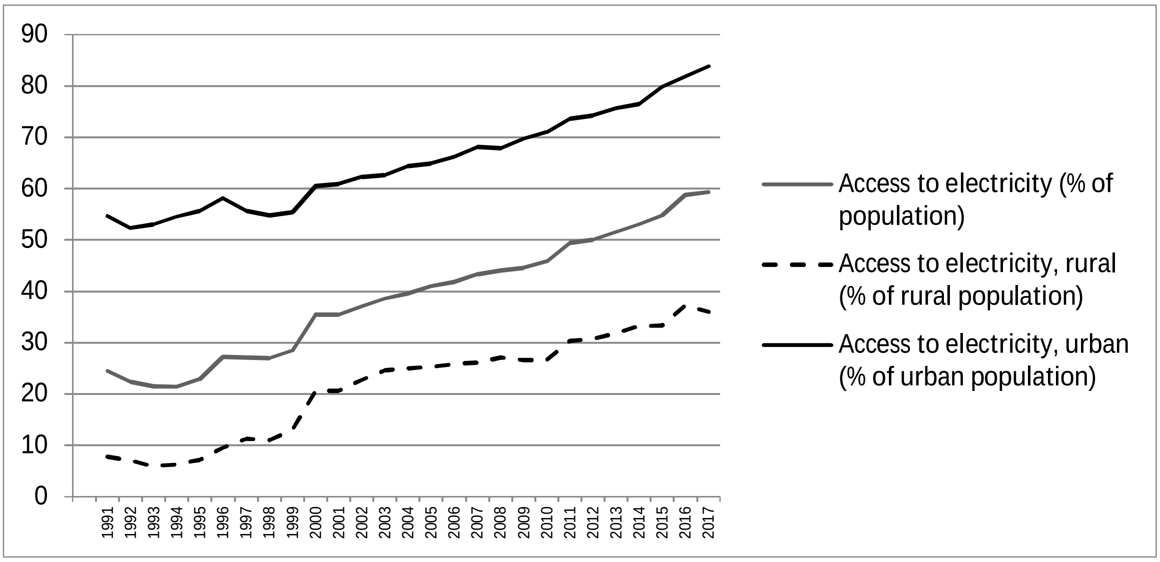
Background: access to electricity in sub-Saharan African countries

An important element in economic research involves understanding the household characteristics, market dynamics and the specific countries' features and conditions. By way of background, we provide a comprehensive picture of the sub-Saharan countries' access to electricity, as well as, for the selected countries and the energy sector's future prospects in the global context.

In a world context, sub-Saharan Africa has more people living without access to electricity than any other world region with more than 625 million people out of 915 million people having no access to electricity in 2012 (IEA, 2014). This accounts for nearly half of the global population living without access to electricity that is 1.2 billion people without access to electricity in 2012 (IEA, 2014). Sub-Saharan Africa is also the only region in the world where the number of people living without electricity is increasing, as rapid population growth is outpacing the many positive efforts to provide access (IEA, 2014). On a more positive note, about 145 million people gained access to electricity since 2000, led by Nigeria, Ethiopia, South Africa, Ghana, Cameroon and Mozambique. Overall, the percentage of the population without access to electricity for sub-Saharan Africa has improved from 77% in 2000 to 68% in 2012 (IEA, 2014).

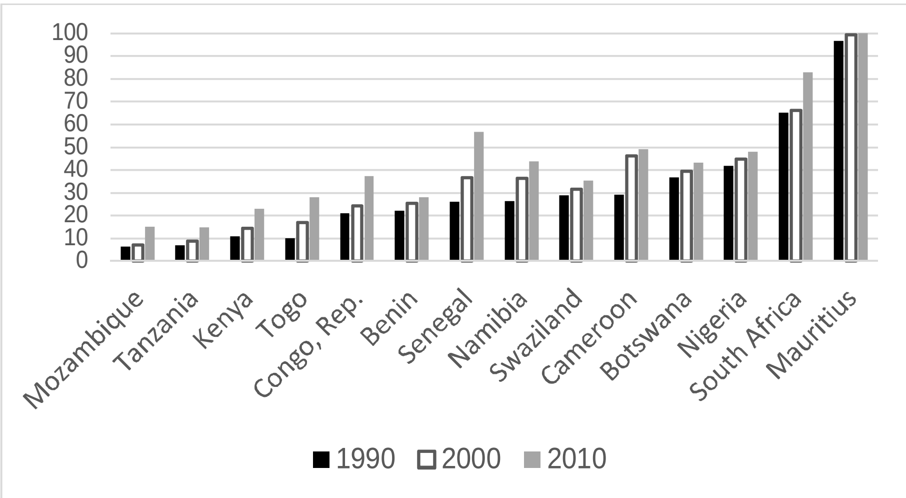
Looking at the demographics of these countries, nearly 80% of those without access to electricity across sub-Saharan Africa are in rural areas (UN-Habitat, 2013). Figure 1 shows not only the lower percentage of population that has access to electricity in rural areas in fourteen sub-Saharan African countries, but also the slower rate of improvement compared to the urban areas for the period 1991 -2016. This is an important characteristic when considering appropriate energy access strategies and technology solutions. Household characteristic from around the world reveals by increasing urbanisation has repeatedly facilitated increasing household access to modern energy. While urbanisation can play a similar role in sub-Saharan Africa, the extent to which this will occur is less clear. This is because sub-Saharan Africa is projected to persist to show substantial growth in both its urban and rural populations which is unlike other world regions (UN-Habitat, 2013). Taking into account these household characteristics, any efforts towards universal modern energy access will require strategic solutions for urban and peri-urban, and most definitely for rural communities in sub-Saharan African region.

Figure 1: Average access to electricity (%total population, %rural population, %urban population)



Source: World Bank (2018)

Figure 2: Access to electricity as a percentage of the population for 14 sub-Saharan African countries for the years 1990, 2000 and 2010.



Source: World Bank (Extracted from World Bank Indicators Database 2016).

Another unique characteristic in sub-Saharan Africa is the rich amount of energy resources, however, these energy resources are not reflected in its low access to electricity data. This is supported by Figure

1 below shows that although the potential energy resources of a country for greater energy usage is an important factor in increasing energy access, it is not the key driver. For instance, Nigeria and The Republic of Congo are oil abundant countries yet both Nigeria and the Republic of Congo have 37.7% and 48%, respectively, of its population living with access to electricity, as illustrated in Figure 2.

In the case of Nigeria, which holds the richest reserves of the oil sector, not only is the country Africa's largest producer but it is the fifth highest exporter of oil in the world. In spite of the country's abundant energy resources, the restrictive factors are the regulatory uncertainty, militant activity and oil theft in the Niger Delta that are deterring investment and production. These factors are deterring investment so much, so that Angola is set to overtake Nigeria as the region's largest producer of crude oil at least until the early 2020s.

In the similar case, the Republic of Congo is the eighth biggest producer of oil in Africa (KPMG, 2013). In spite of the country's abundant oil resources, the Republic of Congo has been unstable from the civil war in 1997. In 2016, the Congolese people are actively demonstrating to secure their right to elect a new head of state because the current president has been in office for 15 years. The somewhat stable economy being enjoyed now has been part of improving the oil sector with more investors considering the country as an investment point.

If the potential energy in the sub-Saharan countries is not a key driver towards access to electricity and economic growth, it is an untapped asset. This untapped asset can be unlocked within the framework of good governance by building the infrastructure for sustainable development (Khennas, 2012). According to a World Bank study, infrastructure contributed to over half of Africa's improved growth performance (World Bank, 2010). However, the constraints faced in this region are the numerous regulatory and political barriers that are holding back investment in domestic energy supply, but inadequate energy infrastructure risks putting a brake on urgently needed improvements in living standards. (IEA, 2014). On a confident note, we find that sub-Saharan Africa is already home to several major energy producers, including Nigeria, South Africa and Angola, and these are being joined by emerging producers, including Mozambique and Tanzania (IEA, 2014)

In light of the infrastructure constraint, this has an impact on the choice of household energy consumption in this region. Household energy consumption in rural areas is characterised by a very high consumption of traditional biomass. Khennas (2012) states that a rural transition from traditional to more modern forms of energy is possible in households, communities and small industries in most developing countries. For instance, in Senegal, the energy transition to modern forms of energy in the residential is slow in urban areas and extremely slow in rural areas, which will further increase the rural-urban divide. Making an allowance for the poor infrastructure in the region, any efforts towards universal energy access will require technology solutions to aid the energy transition.

In light of poor infrastructure found in this region, the supply side interventions for the access to alternative forms of sustainable energy is showing progress. For instance in the Democratic Republic of Congo, where only 37.1% of the population has access to electricity, the co-existence of huge hydropower potential with extreme energy poverty. However due to the limited access to finance, political instability and small market size have all delayed the usage its' hydro resources. These constraints are gradually being lifted, with greater regional co-operation and the emergence of China, alongside the traditional lenders, as a major funder of large infrastructure projects.

In the same light with new hydropower capacity in the Democratic Republic of Congo, Mozambique plays a major role in reducing the average costs of power supply and reducing the share of oil-fired power. The influence of other renewables, led by solar technologies, make a growing contribution to supply, with a successful auction-based procurement programme in South Africa showing how this can be achieved cost effectively. Geothermal becomes the second-largest source of power supply in East Africa, mainly in Kenya and Ethiopia.

Another technology trend is the incentive to use gas within sub-Saharan Africa. This trend is expected to grow with the reforms in the power sector and the approval of gas infrastructure projects. The trend towards gas is seen in Nigeria, which remains the region's largest gas consumer and producer. In addition, the focus for new gas projects also shifts to the east coast and to the huge offshore discoveries in Mozambique and Tanzania.

The outlook for providing access to electricity is bittersweet with nearly one billion people in sub-Saharan Africa are projected to gain access by 2040. This is because of rapid population growth, 530 million people in the region are projected to remain without it at that date (mainly in rural areas) (IEA, 2014). The urgent need to improve access to modern energy to both urban and rural regions implies policies geared towards infrastructure investment supported by public funds and investments.

Literature Review

Energy poverty: definition importance in other studies

To recognise the importance of energy poverty, it is important to understand the definition of energy poverty. While the literature provides many definitions of energy poverty, they all share the similarities in that they all refer to a level of energy consumption that is insufficient to meet certain basic needs (Gonzalez-Eguino, 2015; Sagar, 2005; Reddy, 2000). A definition of energy poverty as presented by Reddy (2000) states, “the absence of sufficient choice in accessing adequate, affordable, reliable, high-quality, safe and environmentally benign energy services to support economic and human development”. The above definition is selected as it acknowledges a number of specific elements to further analyse such as the absence of choice, the role of affordable technology and adequate technology.

To expand on each part of the definition provided above, first we start with expansion of “the absence of choice”. According to Gonzalez-Eguino (2015) and Sen (1999) development starts from individuals not being excluded from those options that enable them to choose and obtain welfare instead of achieving a certain level of income (or energy per capita in this case). In the absence of choice in accessing basic energy requirements, one is deprived of basic services that allow for cooking and heating. Further to this, an individual is deprived of essentials which are fundamental for development as an individual and as a collective. The essentials which allows for participation in education, health, information and in polictics. In the absence of choice to basic energy services it is unlikely to be development.

Second the definition brings to attention the goal of meeting demand for “energy services”. Gonzalez-Eguino (2015) states that the goal is for the provision of energy services from the different sources of energy rather than energy consumption per se. The different types of energy services make up the primary sources, such as, coal, oil, gas, biomass, etc.. These primary sources are then processed and the energy is stored to be distributed via the different energy “vectors” (heat, electricity and solid, liquid or gasous fuel). This is for the purpose of providing the different energy services which are really essential, such as lighting, heating, cooking, cooling, work, transportation, access to information and communication technologies.

In looking at the primary energy services and energy vectors used by a country, Gonzalez-Eguino (2015) shows they may vary widely depending. The energy services and energy vectors selected depends on geographical characteristics, energy policy implemented and the stage of development in a given country. However the energy services demanded are similar all over the world such as such as, coal, oil, gas, biomass, etc.. With regards to the stage of development, it is seen that wealthier countries tend to have various energy services available, while in poorer countries and particularly in rural areas tend to have few alternatives or none at all.

This is further supporteded and elaborated by Bailis (2012) research of the various energy soucres used for cooking in different African countries and accounts for the wealth quantiles. He found that in Burkina Faso and the Central African Republic the options avaiable for cooking is between burning wood or charcoal. Whereas, in Kenya and South Africa, gas and electricity are more widely avaiable.

The third part of definition focuses on essential characteristics of the technologies used to access energy services and the need to be “adequate”. Gonzalez-Eguino (2015) highlights that “adequate” technologies should be suited to the geographical characteristics, knowledge base and the culture of the area. He further brings to awarness that too often development aid projects fail if they simply replicate the use of the same technologies in different locations. This is due to not taking into account the particular characteristics of each region or community.

Specifically, the technologies chosen should be “affordable” that is as cheap as possible to alternatives available. In the research looking at household behaviour relative to energy services Kroon et al. (2013)

present that low-quality fuels are displaced by higher quality, more versatile fuels as income increases which is known as the "energy ladder" theory. The progress from "affordable" energy sources is supported by the literature (Gonzalez-Eguino, 2015; Hosier & Dowd, 1987; Heltberg, 2004) stating that as an average household income levels rise, fuel sources such as biomass tend to be replaced by sources such as kerosene, oil and ultimately electricity. With electricity recognised as the cleanest most versatile energy vector of all.

One main caveat should be mentioned when discussing the energy ladder theory is that the cheapest energy vector option is not always the low-quality fuels, with most cases are the only option. Foster et al. (2000) has shown that in Guatemala when measuring the cost per unit of energy service, it reflected the complete opportunity cost was likely more expensive when accounting for the time taken in collecting wood or low-quality/traditional fuel sources. However this study did not capture the opportunity cost of air pollution generated from these traditional fuels and its impact on human health. When considering Kanagawa and Nakata (2008) study which takes into account health and pollution impacts, it shows that the cost per unit of energy services of low-quality fuels is more expensive.

The definition mentions "reliable and safe" in the energy technologies. Reliable technologies are needed which are not likely to experience continual breaks in service (Gonzalez-Eguino,2015; Nussbaumera et al., 2012). As the instance in South Africa and many other countries with power cuts can lasting for several hours a day are common.

Safe technologies are needed that are not liable to endanger the health for all those within the household (Gonzalez-Eguino, 2015; Nussbaumer et al., 2012). Majority of rural household use energy options that burn organic material such as wood, dung or charcoal (biomass fuel) for cooking, heating and lighting. This form of energy option is linked with high levels of indoor air polluting emissions for all those within the household. These emissions are associated with an increase in the incidence of respiratory infections, including tuberculosis, pneumonia, and chronic obstructive pulmonary disease, low birthweight, cataracts, cardiovascular events and all-cause mortality both in adults and children (Fullerton et al., 2008).

Finally, the definition mentions technologies should be "environmentally benign" that is that they should not compromise future generations (Gonzalez-Eguino, 2015). One main argument should be mentioned, the trade-off between energy poverty reduction and climate change mitigation. The study by Massimo and et al. (2011) shows by increasing energy for the poorer population, this will not lead to a significant rise in temperatures or emission. This is supported by Pachauri & Spreng (2004) that shows universal access to modern energy which is a complete rural electrification will not have a significant impact on climate change. The reason for this finding is that currently biomass is being used for cooking with the idea that there are no emissions associated with this biomass. Taking the emissions emitted with biomass into account such as the greenhouse gases (such as ethane and carbon monoxide) and then replacing biomass with modern energy there is an overall reduction to the level of emissions. In shifting away from biomass, there is a big efficiency gain because you are substituting a large amount of inefficient biomass with very small amount of gas or another important modern energy is being used for cooking.

Impact of Electricity on Income Generating Activities

To precede, this paper demonstrates the link between energy poverty and socio-economic growth in sub-Saharan Africa and developing countries experiences. The recent literature on electrification emphasises and argues that it enables livelihoods in a number of ways (Peter et al., 2009; Prasad & Dieden 2007; Kirubi et al., 2008; China see, Fan & Chan-Kang, 2002; Cook, 2013). This implies that electrification stimulates employment and income generating activities, whereby people can build assets through micro/small sized production activities such as a car repair workshop. The argument presents electrification to enable these micro/small entrepreneurs to generate income and surplus resource (extra income) that lead to the emergence of credit and savings schemes. Notably, the impact of electric lighting is likely to reduce women's burden in fetching wood and using a wood burning stove (Cook, 2013).

The on-going dilemma of rural enterprises in developing countries is that capital intense, electric machinery potentially replaces labour. By way of comparison, labour is cheaper however the poorly educated fail to recognise the potential uses and benefits of the new methods of production. This slow transition of a labour to new methods of production is discussed earlier as the poverty trap (Azariadis, 1996) and is reaffirmed in the study by Peter et al. (2009). He examines the impact of developing rural electricity with just financing hardware and civil works without complimentary services or instead with complimentary services. In his study complimentary services refers to the support to learn and how to use electricity. Additionally, complimentary services comprise of campaigns to raise awareness amongst households, enterprises and social institutions of the advantages and disadvantages of electricity. The targeted campaigns also included the commercial electricity users which covered business development services, consumer and micro-finance services and other infrastructure such as telecommunications and transport (Kirub et al., 2008; Cook, 2013; Brew-Hammond, 2009)

To point to the case in Kenya and Nepal, where utility providers offered these complimentary services. Specifically in Kenya, the Kenya Power and Lighting Company as the national utility provider used this approach. They installed 500 rural electrification schemes covering health, schools and community water in rural Kenya costing US$ 30 million (KPLC, 2007). Similarly in Nepal, Bastakoti (2006) study of rural electrification debates complementary service systems and policy co-ordination are necessary pre-conditions for the effective use of electricity power in rural communities.

The difficulty of assessing the impact of electrification on opportunities towards income generation is to distinguish the effects of existing connections to electricity as opposed to the effects provided by new connections. One study that made that clear distinction is Prasad & Dieden (2007) for South Africa. The study uses household survey data from 1995 to 2004 and examine the impact of electrification on the development of micro, small and medium sized enterprises with including people self-employed amongst the households. Their results estimated that between 40% and 53% of the increase in the enterprise activity was attributed to the extension of the electricity grid, thus indicating that enterprise growth was higher amongst those already connected.

This was reaffirmed by Kirubi et al., (2008) conducting fieldwork in Kenya. They reported that electricity enabled the use of electric power tools and equipment which resulted in an increase in productivity of the enterprises studied. This finding is in keeping with studies of other developing countries infrastructure sectors. For example, Kanagawa and Nakata (2006) reveal in the case study of the positive socio-economic impacts of rural households switching from stoves to using biomass fuels to gas stove. In the literature mentioned above they argue the benefit of electrification thereby reduces local pollution and allows for socio-economic growth. However, Cook (2013) briefly concludes that it is difficult to draw firm deductions from empirical studies and case studies that have attempted to access the impact that rural electrification has had on income generating activities thus the desired impact on economic growth.

In Zimbabwe, a study by Mapako and Prasad (2008) adopted a different approach to examining the effects of electrification by focusing on end user perspectives. The main contributor to rural electrification was made possible as a result of extensions to the grid. This study surveyed 73 enterprises in Matebeland and concludes electrification increased the number and scope of small enterprises and increased employment. In addition, the main concern from respondents was less about high tariffs and more concerned about reliable supply of electricity.

However, there are studies that provide a more negative view on the link with electrification. Wamukonya and Davis (2001) study in Namibia reports electrification did not have a significant impact on the growth of income-generating activities in rural areas. The study found that amongst households without electricity generated the highest home-based income generating activities. In their study home-based activities covered basket weaving, cake making and welding with few homes based enterprises needed electricity except for lighting. Most enterprises that needed electricity started before electrification. In respect to the source of electricity that is whether from the utility grid or solar powered energy, had no effect on the overall findings.

In Malawi, a study focused on the effects of lanterns for lighting by Adkins et al. (2010). This study, found little evidence for the link between electric lighting and income generation. In their study, they observe the innovative use of lanterns that use lighting emitting diodes (LEDs) powered by batteries and charges by grid or small solar panels. LED lanterns have merged as a relatively cost effective substitute to kerosene and other fuel-based lighting technologies. By way of comparison, LED lanterns provide a brighter light and last longer than fuel-based technologies. However, little evidence was found for a clear connection with income generating activities. They did find that with the use of LED lanterns was a change in households lightning patterns with a decrease in their reliance on tradition lighting sources and reduced their fuel purchases.

While the studies mentioned above show the link to income generation, the benefit of rural electrification is broader. Many studies have sought to broaden the argument beyond income generation. As Cook (2013) study shows these benefits covers the effects on quality of education, gender equality, health and poverty reduction (For an example in China see, Fan & Chan-Kang, 2002). This is affirmed in Zambia, a study by Gustavsson (2007) reveals the educational benefits resulting from solar technology. Their study could not measure the impact directly onto school children's marks however the more time was spent reading and studying as a result of electrification. This study does suggest further research to examining the effects of income generation through strengthening education and are more likely to be measurable in the longer term.

Finally, the vast literature writes about the future of the energy sector, particularly González-Eguino (2015) mentions the energy sector have been extensively analysed in the terms of energy security and climate change however with less analyse of energy poverty. In addition, the UN's Millennium Development Goals (2000) whose objective is to eradicate extreme poverty, improve living conditions and facilitates progress towards sustainable development; however the Millennium Development Goals do not include any mention of access to energy. Specifically Cecelski (2000) mentions in a paper to the Asia Alternative Energy Unit, that there are very few empirical studies demonstrating a linkage between energy strategies and poverty reduction. Since Cecelski (2000) call for empirical studies on energy poverty, there has been a number of case studies (Kirubi et al., 2008; Prasad & Dieden, 2007; Sagar, 2005) demonstrating regional specific change to strategies and the impact on poverty in developing countries.

Methodology

Model specification and data

The theoretical framework of this study is based on the one side on the discussion of the definition of energy poverty and its aspects above and the concept that economic growth and development depend on the "quality" of the population. In other words, the demographic characteristics of the country may contribute to the economic conditions. Furthermore, looking at the SDGs that are linked and provide synergic function with SDG8: Economic growth and decent employment are primarily the ones associated with access to energy (SDG7), quality education (SDG4), sustainable cities and communities (SDG11).

Based on this the estimated economic model is as follows:

$$GDP_{it} = a_{it} + \beta_i GDP_{t-1} + \gamma_i ACCESSELEC_t + \delta_i URBANIZATION_t + \zeta_i POPULATION + \eta_i EDUCATION_t + u_{it} \quad \text{Eq1}$$

In the specified economic model, the dependent variable is GDP is the Gross Domestic Product per capita of country i in period t as a measure of economic growth. The independent variable in focus is the access to electricity (ACCESSELEC) defined as the percentage of population with access to electricity, used as a proxy for energy poverty with an expected positive relationship with the dependent variable.

The independent variables are all capturing the characteristics of the population of the countries in the sample: how fast the population grows POPULATION (annual population growth): the impact of higher population is expected to be positive to the GDP for sub-Saharan countries as the demand for goods and services will increase and with that the production while at the same time, the increase of population will increase the labour force available for economic production, whether the population stays in urban areas in its majority URBANIZATION (%share of people living in urban areas): the expected effect of urbanization as per the literature is ambivalent – on the one side, higher share of population concentrated in urban areas will create a bigger pool of potential employment and hence higher economic growth, while at the same time, high urbanization rates without proper planning can hinder economic growth at a national level, if the population is having adequate education EDUCATION (total enrolments in primary education): the expected effect of higher levels of educated population and hence, skilled labour, is positive – however, due to data constraints, the proxy for education being enrolments for the country group might not make a significant impact to economic growth as in these countries, the drop-out rates remain high. All variables are used in their natural logarithmic form.

The empirical analysis is based on a fixed effects panel data estimation with cross-sections consisting of fourteen sub-Saharan African countries (Benin, Botswana, Cameroon, Congo – Republic, Kenya, Mauritius, Mozambique, Namibia, Nigeria, Senegal, South Africa, Swaziland (Eswatini), Tanzania and Togo) for the period 1990 to 2016.

The number and selection criteria of these countries are limited due to data availability of the independent variables linked to the access to electricity. The model comprises of annual data for the selected year from the World Bank Development Indicators.

In Table 1, we include a summary of the main variables descriptive statistics in their units of measurements, while Table 2 presents a summary of correlation coefficients. From Table 2, it can be observed that all independent variables are highly correlated with the dependent variables; ACCESS, ENROL and URBAN all have a positive correlation coefficient while POP a negative one.

Table 1: Descriptive statistics of all variables

	ACCESS?	GDP?	POP?	SCHOOL?	URBAN?
Mean	41.55791	2703.246	24062953	99.35393	40.11974
Median	38.68081	1383.677	9404302.	103.2053	40.39200
Maximum	100.0000	10199.48	1.91E+08	132.4668	68.70000
Minimum	2.282847	200.2979	866993.0	53.41250	17.34200
Std. Dev.	23.60584	2401.577	36543455	16.51676	13.09034
Skewness	0.727172	0.958890	2.629217	-0.688016	0.253900
Kurtosis	3.140025	2.779731	9.972972	3.069158	2.175022
Jarque-Bera	27.84031	56.51709	1156.814	24.28174	14.23317
Probability	0.000001	0.000000	0.000000	0.000005	0.000812
Sum	13007.62	983981.7	8.76E+09	30501.66	14603.59
Sum Sq. Dev.	173857.5	2.09E+09	4.85E+17	83477.79	62202.62
Observations	313	364	364	364	364
Cross sections	14	14	14	14	14

Table 2: Correlation coefficients

	GDP	ACCESSELEC	EDUCATION	POPULATION	URBANIZATION
GDP	1.000				
ACCESS	0.801	1.000			
ENROL	0.939	0.709	1.000		
POP_GR	-0.829	-0.788	-0.852	1.000	
URBAN	0.990	0.870	0.912	-0.830	1.000

Before estimating the regression, the data will be tested for unit roots, The chosen test was the one proposed by Im et al. (2003) and Levin, Lin and Chu (2002) that tests for unit roots allowing heterogeneous autoregressive coefficients. The motivation for using the fixed effects estimator approach is based on work by Deaton (1985). The selection of fixed effects estimator approach is further supported by the results of the Hausman test for this data set (Rejected the null hypothesis of No misspecification (Random effects estimation) to the alternative of Fixed Effects).

In the case of controlling for potential endogeneity and multicollinearity of variables we add the two step system Generalized Method of Moment (GMM). According to Arelano and Bover (1995) this method is able to control for econometric issues such a cross-sectional dependence of countries and multi-collinearity among variables which are predominant in panel econometric models. Furthermore, the method produces more efficient parameters estimates especially in the case of endogeneity and multicollinearity. The dynamic GMM panel estimator exploits the dynamic relationships inherent in the explanatory variables.

Empirical Results

Before proceeding with the estimations, the results of the IPS and LLC unit root tests for the panel of the series are presented in Table 3. The results denote the absence of non-stationarity for the overall panel, when a common unit root is tested.

Table 3: Unit root tests results

ALL VARIABLES (COMMON UNIT ROOT)		
Method	Statistic	Prob.**
Null: Unit root (assumes common unit root process)		
Levin, Lin & Chu t*	-4.62238	0.0000
Breitung t-stat	3.07224	0.9989
Null: Unit root (assumes individual unit root process)		
Im, Pesaran and Shin W-stat	-2.55662	0.0053
ADF - Fisher Chi-square	100.409	0.0002
PP - Fisher Chi-square	164.337	0.0000
GDP		
Method	Statistic	Prob.**
Levin, Lin & Chu t*	-3.85987	0.0001
Breitung t-stat	3.11810	0.9991
Im, Pesaran and Shin W-stat	-1.87836	0.0302
ADF - Fisher Chi-square	50.2548	0.0061
PP - Fisher Chi-square	63.3266	0.0002
ACCESS		
Method	Statistic	Prob.**
Levin, Lin & Chu t*	-2.90465	0.0018
Breitung t-stat	0.55204	0.7095
Im, Pesaran and Shin W-stat	-1.74383	0.0406
ADF - Fisher Chi-square	50.1540	0.0062
PP - Fisher Chi-square	101.010	0.0000

URBAN		
Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.39563	0.3462
Breitung t-stat	3.02064	0.9987
Im, Pesaran and Shin W-stat	1.94866	0.9743
ADF - Fisher Chi-square	35.3649	0.1595
PP - Fisher Chi-square	34.2814	0.1918
EDUC		
Method	Statistic	Prob.**
Levin, Lin & Chu t*	-0.45853	0.3233
Breitung t-stat	0.14933	0.5594
Im, Pesaran and Shin W-stat	0.36152	0.6411
ADF - Fisher Chi-square	32.6110	0.1737
PP - Fisher Chi-square	19.4977	0.8147
POP		
Method	Statistic	Prob.**
Levin, Lin & Chu t*	9.02504	1.0000
Breitung t-stat	-8.48937	0.0000
Im, Pesaran and Shin W-stat	7.54407	1.0000
ADF - Fisher Chi-square	59.0617	0.0005
PP - Fisher Chi-square	10.0091	0.9993

The primary focus of the estimations is the impact of the access to electricity as an explanatory variable to GDP. The control variables added follow a sequence with five different specifications as a robustness check in the following one-by-one sequence Model (3) urbanization, Model (4) population, and Model (5) education. The Fixed Effects estimation results are presented at the Appendix – Table 4.

Table 4: Fixed effects estimates

GDP	(1)	(2)	(3)	(4)	(5)
GDP (-1)	1.011***	0.995***	0.954***	0.944***	0.950***
ACCESSELEC		0.010***	0.011***	0.012***	0.009***
URBANIZATION			0.151***	0.171***	0.147***
POPULATION				-0.013*	-0.012**
EDUCATIONL					0.031**
Observations	364	364	364	364	333
R-squared	0.999	0.999	0.999	0.999	0.999
Number of countries	14	14	14	14	14
F- Test	50.121***	48512.65***	48975.01***	4464.45	51391.3***

*Note: *, **, and *** indicates significance at 10, 5 and 1 percent, respectively. P-values in parentheses.*

As mentioned in the methodological discussion, a GMM estimator is able to control for econometric issues such a cross-sectional dependence of countries and multi-collinearity among variables, and hence the results might be dissimilar to those of the fixed effects estimation. So, Table 5 reports the estimates of access to electricity on GDP using the GMM estimator.

Table 5: GMM estimates

GDP	(1)	(2)	(3)	(4)	(5)
GDP (-1)	1.001***	0.988***	1.012***	1.005***	1.008***
ACCESSELEC		0.095***	0.103***	0.117***	0.120***
URBANIZATION			-0.162***	-0.155***	-0.156***
POPULATION				0.092**	0.098**
EDUCATION					-0.015
Observations	377	377	377	364	333
R-squared	0.935	0. 943	0.942	0.999	0.938
Number of countries	14	14	14	14	14

*Note: *, **, and *** indicates significance at 10, 5 and 1 percent, respectively. P-values in parentheses.*

Each of the regressions show that all the access to electricity coefficients are positive and statistically significant against GDP growth. This suggests that a reduction in energy poverty is beneficial to economic growth: the coefficient ranges between 0.095 and 0.120. To be specific, as seen in column 2 of Table 5, an increase by 1% in access to electricity leads to an increase of 0.095% in the annual growth rate. When factoring the control variables for the need of robust testing as shown in column 5, an increase by 1% in access to electricity leads to an increase of 0.120% in the annual growth rate. More specifically, access to electricity proved to be a robust macroeconomic determinant of growth, which highlights its important role in determining economic activity in the region. .

The empirical investigation found a positive and significant relationship between access to electricity and economic growth. In particular, access to electricity proved to be a robust macroeconomic determinant of growth, which highlights its important role in determining economic activity in the region. What is of importance is the multiple benefits that the economy will receive at a later stage from an increase in people with access to electricity. These associated benefits are the effects on quality of education, gender equality, health and poverty reduction socio-economic development for that household.

Conclusion

The aim of this paper is to examine energy poverty in relation to economic growth in the context of developing and poverty-suffering countries with a focus on fourteen sub-Saharan African countries. To do so, a GMM model is estimated for the period 1990 to 2016. The measurement of the dire level of energy poverty in sub-Saharan Africa can be shown in the percentage of the population without access to electricity, which accounted for 57% in 2016. This implies in the sub-Saharan Africa it is a priority for the supply of reliable, affordable and widely available energy, as well as, for the critical development of this region. This paper shows the results of this research is relevant given many sub-Saharan African countries are in a unique position of shifting investment in the energy sector as traditional forms of energy production are being replaced by modern sustainable energy options. The empirical investigation found that access to electricity is a positive contributor to this group of countries' economic growth, with relatively low impact on a direct basis. This study provides evidence for the direct effect and also, raises the issue of all the health, education, income generating impact that access to electricity will provide to future generations.

This paper provides a view in answering the research question of what are the household characteristics in sub-Saharan Africa in response to access to electricity, as well as, what the effect of selecting the energy option of electricity infrastructure towards economic growth is. This result is added to the recent literature on electrification that states access to electricity is a positive contributor to the livelihoods of households in a variety of ways, affecting for example the living standards from a health perspective, or promoting income generating opportunities, or even decreasing the burden of females, usually, that they used to walk long distances to provide their households with wood sources (Peter et al., 2009; Prassad & Dieden, 2007; Kirubi et al., 2008; Cook, 2013). This paper found vital lessons that can be considered to have policy implications. The four vital lessons have emerged from the literature review, case studies and empirical results in order to reach the goal of increasing the access of energy in sub-Saharan African countries.

The first lesson stems from the empirical results that is the need to increase access of electricity as this will contribute to a positive and significant benefit to economic growth. The second lesson is the need for long term strategies and large scale programmes which is only possible with large financial resources. The third lesson follows from the second, when rolling out energy infrastructure it should be required to include small scale decentralised regions as this is the only likelihood of increasing access of energy services to poor people. The last lesson and often over looked given that it is not the major barrier faced is the cultural and social issues. These issues are found when household shift from traditional forms of energy services (biomass) to safer and reliable forms of energy services (electricity and gas).

To conclude, the fourteen sub-Saharan African countries' experience is informative because it exemplifies the importance of access to energy, particularly in developing and relatively poor countries. This information is worth noting for particular institutions, such as independent and well-staffed organisations conducting investment into the regions infrastructure. Moreover, it signals to government in these region that priority should be given to policies that intend to increase the access of electricity to households within their country. The rate of urbanization is also a factor that should not be overlooked: the differences between energy poverty in urban and rural areas might explain partially the differences in development and growth between these areas. These differences have been considered one of the reasons that African countries cannot pick up on economic growth: two-tier economies that are in need of appropriately structured and implemented policies – certainly a topic for further research, data permitting.

As per Gonzalez- Eguino (2015) quoting a report by IEA, “the cost of providing universal access to energy by 2030 would require annual investment of $35 billion, i.e. much less than the amount provided annually in subsidies to fossil fuels”. Hence, significant investment and allocation of resources is essential. In current constrained economic conditions, the net benefit of such investment should be estimated: the cost of the investment in providing access to energy infrastructure vis-à-vis the economic benefit associated with the improvement of living standards and essentially economic development. In this study, we have provided some quantitative evidence for the impact that access to electricity can potentially have to economic growth. Winkler et al. (2011) also concluded the importance of access to electricity for the economy in developing countries, drawing the attention however to the issue of affordability of using energy services.

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Appendix

Insert Table 4