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„The Multidimensional Energy Poverty Index (MEPI) and Nigeria – questioning the relevance of current energy reforms“

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For my beloved father

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LIST OF ABBREVIATIONS

%	Percent
BSCF	Billion standard cubic feet
ktoe	Kilotonne of oil equivalent
kV	Kilovolts
kVA	Kilovolt-ampere
kW	Kilowatt
kWh	Kilowatt-hour
mb/d	Million barrels per day
Mtoe	Million tonnes of oil equivalent
MVA	Megavolt ampere
MW	Megawatt
TWh	Terawatt-hour
UHV	Ultra High Voltage
W	Watt

A	Intensity ratio of energy poverty
ANOVA	Analysis of Variance
DHS	Demographic and Health Surveys
Discos	Distribution companies
ECOWAS	Economic Community of West African States
EDI	Energy Development Index
EEEP	ECOWAS Energy Efficiency Policy
EIU	Economic Intelligence Unit
EPSRA 2005	Electric Power Sector Reform Act 2005
EREP	ECOWAS Renewable Energy Policy
FCT	Federal Capital Territory
GDP	Gross Domestic Product
Gencos	Generation companies
GHG	Greenhouse Gas
GLS	Generalized Least Squares
GNESD	Global Network on Energy for Sustainable Development
H	Headcount ratio of energy poor
HDI	Human Development Index

ICTs	Information and Communication Technologies
IEA	International Energy Agency
IPP	Independent Power Project
LEEDS	Local Economic Empowerment and Development Strategy
LPG	Liquefied Petroleum Gas
MDGs	Millennium Development Goals
MEPI	Multidimensional Energy Poverty Index
MIS	Malaria Indicator Survey
MPI	Multidimensional Poverty Index
MYTO	Multi-Year Tariff Order
NBET	Nigeria Bulk Electricity Trading Plc
NEEDS	National Economic Empowerment and Development Strategy
NERC	Nigerian Electricity Regulatory Commission
NESI	Nigerian Electricity Supply Industry
NIPP	National Integrated Power Project
PACP	Presidential Action Committee on Power
PHCN	Power Holding Company of Nigeria
PIB	Petroleum Industry Bill
PPAs	Power Purchase Agreements
PPP	Purchasing Power Parity
PPPs	Private-Public Partnerships
PTFP	Presidential Task Force on Power
REA	Rural Electrification Agency
REF	Rural Electrification Fund
REMP	Renewable Energy Master Plan
SDGs	Sustainable Development Goals
SEEDS	State Economic Empowerment and Development Strategy
SE4ALL	Sustainable Energy for All
TCN	Transmission Company of Nigeria
TEA	Total Energy Access
TRES	Total primary energy supply
UN	United Nations
USAID	United States Agency for International Development
WLS	Weighted least squares

INTRODUCTION

Energy is essential for industrial development, economic growth and prosperity, and as such, is a prerequisite for human beings to meet their developmental aspirations. This, in turn, serves to minimize climate risks and create jobs and economic competitiveness, ultimately alleviating poverty and stimulating energy efficiency, thus improving human welfare and global health (Li et.al, 2013; Srivastava et.al, 2012; Bazilian/Yumkella, 2012; Bazilian et.al, 2012; Bazilian et.al, 2010a; Bazilian et.al, 2010b; IEA, 2014; Pereira et.al, 2010; Oyedepo, 2012; PECN, 2003).

Recognizing the importance of energy access and arguing the diverse nature of energy poverty, this paper seeks to explore the various factors and relationships that influence the level of energy deprivation, on the example of Nigeria. To investigate this, we firstly utilize the newly proposed Multidimensional Energy Poverty Index (MEPI) as the most appropriate method to demonstrate the respective energy consumption patterns of Nigerian households. Slightly modifying this method to correct some omissions related to missing data and coming up with the specific data treatment for Nigeria, we further turn to multiple regression analysis with the purpose of reconfirming or rejecting the relationship between the individual indicators and the energy deprivation level in the country. Finally, questioning the relevance of current energy reforms to address the needs of the energy poor in Nigeria, we argue that the empirical evidence derived from this analysis could establish a foundation for effective and targeted planning and implementation of poverty-inclusive policies.

The structure of this paper proceeds as follows: Chapter 1 briefly considers the relevant literature on energy access and energy poverty, with an aim to outline the existing approaches and methodologies in identifying the latter. Chapter 2 applies the MEPI to capture and analyze the energy poverty situation in Nigeria, while further verifying the results through inferential statistics. Providing context to these analyses, the current energy scenario and related national energy policies and frameworks in the country of focus are discussed in Chapter 3. Finally, Chapter 4 discusses the advantages and limitations of the MEPI, while simultaneously exploring the main policy implications of this study for improved decision-making in the sphere of energy poverty alleviation in Nigeria.

CHAPTER 1. Energy Poverty and Energy Access

According to the World Energy Outlook 2014, 1.3 billion and 2.7 billion people lacked access to electricity and used traditional biomass for cooking in 2012, respectively. Analysis shows that Sub-Saharan Africa is the most electricity-deprived region in the world; more than 620 million people live without electricity access, 93 million of which live in Nigeria, making it host to one of the largest populations without electricity access. The key causes of this global trend are rapid population growth, unreliability of national grids, and poor generation, transmission and distribution capacity. While the World Energy Outlook 2014 analysis of existing and planned government policies predicts the rapid growth of the region and significant improvements in power capacity with an increase in renewable energy usage, per capita consumption is still expected to be less than 720 kilowatt-hours (kWh), with 530 million people without electricity access by 2040 (IEA, 2014).

In order to fully grasp the cause and effect of limited energy access and to identify the most appropriate methodology for our further empirical analysis, we will briefly review and analyze the literature on energy access and energy poverty, outlining the existing approaches and contentions regards physical availability, adequacy, affordability, reliability, etc. and their potential limitations in defining energy access and energy poverty.

1.1 Literature Review

An increased recognition of the significance of energy access and the need to combat energy poverty is clearly visible across a number of joint initiatives, dedicated events and research papers on the topic. Currently, the international community is actively involved in discussing the post-2015 development agenda and establishing the goals, targets and indicators for the Sustainable Development Goals (SDGs). Unlike the Millennium Development Goals (MDGs) that did not distinguish energy as a separate goal, the SDGs, to the contrary, reconfirm the importance of energy access while including it as one of the 17 goals, primarily targeting improvements in energy efficiency and the expansion of renewable energy in the total energy mix by 2030 (Bazilian et.al, 2010a; Pachauri, et.al, 2004; Pereira et.al, 2010; Osborn et.al, 2015).

The Sustainable Energy for All (SE4All) initiative, launched by the United Nations (UN) Secretary-General with the outlined vision to be achieved by 2030, the International Year for Sustainable Energy for All declared in 2012, the UN Decade of Sustainable Energy for All 2014-2024, the result of the aforementioned, and the formation of the Green Climate Fund, etc. further highlight the potential of modern[1] energy access to become a crucial opponent to energy poverty (Bazilian et.al, 2012; Pachauri, 2011; UN, 2011; www.se4all.org; www.gcfund.org).

Nonetheless, neither energy access nor energy poverty is a universally defined term. One of the commonly used definitions, originally proposed by the International Energy Agency (IEA) in 2002 and later modified, refers to modern energy access as *“household access to a minimum level of electricity; household access to safer and more sustainable cooking and heating fuels and stoves; access that enables productive economic activity; and access for public services”* (IEA, 2014, p.704). Complementing this definition, the IEA further divides access to energy services between basic human needs, productive uses and modern society needs, defining these based on kWh electricity consumed per person per year and key development needs. In this approach, the absence of modern energy access automatically implies energy poverty and thus, can be used as a benchmark (IEA, 2010; Pereira et.al, 2011; Bazilian et.al, 2010a; Srivastava et.al, 2012).

While this definition of energy access can be classified as quantitative, the literature on energy access and energy poverty is typically divided along poverty and access, economic, and engineering based approaches, as well as supply and demand side perspectives (Pachauri et.al, 2004; Li et.al, 2013; Bazilian et.al, 2010a; Barnes et.al, 2011).

Before providing an overview of the different approaches that have been used to define energy poverty and energy access, it is important to note that energy in itself is divided between primary, end-use or useful energy consumed, whereas the actual services themselves (e.g. warm housing, cooked meals, etc.) derived from useful energy and ideally secured by efficient and sustainable forms of energy and appliances, are of the highest value to people (Pachauri et.al, 2004; Pachauri, 2011; Kaygusuz, 2011; Bazilian et.al, 2010a). Therefore, it is not surprising that the level of

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[1] The term “modern” is used to distinguish between traditional and improved, clean forms of energy and/or energy appliances (IEA, 2014; Brew-Hammond, 2010).

energy consumption often corresponds to the level of socio-economic development and welfare of the nation (Oyedepo, 2012; Pachauri et.al, 2004; Nussbaumer et.al, 2011; Nussbaumer et.al 2013; Apere/Karimo, 2014).

A large share of the literature on energy poverty and energy access discusses the physical availability of modern energy and/or physical access to energy services as the means to measure energy poverty. Pereira et. al. (2011), for example, associate the availability of energy with access to electricity and thus, while analyzing the impact of grid expansion in rural parts of Brazil, observe a clear correlation between access to electricity and alleviation of energy poverty and inequality. Sovacool et. al. (2012) advance a step further and propose to include mechanical power and mobility alongside other energy services, such as lighting, heating and cooking, therefore highlighting the multidimensional aspects of energy poverty. This approach, however, seen from the perspective of geographical coverage only, does not address such issues as the quality and quantity of supply (Pachauri et.al, 2004; Pachauri, 2011; Brew-Hammond, 2010; Barnes et.al, 2011).

The affordability, or the so called economic-based, approach investigates overall expenditure on energy versus the average total household income, therefore expecting energy to be affordable to all income groups. Often using 10% of income spent on energy as a threshold below which households are considered to be energy poor, this approach reveals that impoverished households normally allocate a larger share of their budget to energy than wealthier households. The same conclusion was also attained by Foster et. al. (2010) while estimating a net price of useful energy consumed among income poor households. Their conclusion, however, was based on the false assumption that income poor are automatically energy poor and vice versa, which has attracted criticism from numereous authors. The costs associated with the efficient technologies and appliances needed to use the energy, as well as non-monetary transactions that usually occur in developing countries where fuel wood is considered free and barter is rather common, are also not examined in this approach (Srivastava et.al, 2012; Barnes et.al, 2011; Pereira et.al, 2011; Pachauri, 2011; Pachauri/Spreng, 2011).

Furthermore, while investigating the difference between fuel and energy poverty, Li et. al. (2013) argue that affordability is largely a matter of concern for the fuel poor, who are usually residents of developed countries with cold climates; whereas availability refers to energy poverty, usually an affliction of those living in poor countries irrespective of climate conditions. Other researchers, however, have argued that both affordability and availability are two important and interconnected indicators (Brew-Hammond, 2010; Apere/Karimo, 2014; Oyedepo, 2012). Bazilian et. al. (2011) used both physical availability and affordability of energy products to define energy security in their analysis of the impact of the latter versus climate change on investment decisions in South Africa, while Bhide and Monroy (2011), for instance, named cultural preferences along with affordability and availability as the key incentives to shift from traditional to modern fuels.

Another oft-discussed method to define energy poverty, classified under the engineering approach, estimates the basic energy needs of a person to sustain a decent level of living standards; therefore enabling them to establish a minimum threshold quantity of energy services required, below which the household is considered to be energy poor (Pachauri et.al, 2004; Pachauri, 2011; Pereira et.al, 2011; Barnes et.al, 2011; Bazilian et. al, 2010a). This proposed method can be calculated from both the demand and supply-side perspectives (Pachauri, 2011; Barnes et.al, 2011). For instance, IEA (2014) has established a minimum threshold of 250 kWh and 500 kWh electricity consumed per five-person household, per year, for urban and rural households, respectively, while Pachauri et. al. (2004) use 15 watt (W) of average power consumption, which would represent 131.4 kWh of useful energy needed, per person per year in a five-person household, as a bottom cap or “abject” poverty level in India. The IEA (2014) proposed consumption level anticipates the use of two light bulbs and some additional gadgets, whereas Pachauri et. al. (2004) initially include only one warm meal per day, a kerosene lamp and hot water, gradually increasing the variety of energy services to reflect the change in well-being of a dweller.

Proponents argue, however, that this approach relies on arbitrary assumptions that lead to subjective selection of the basic energy services that should be included in the minimum energy basket, as they can vary greatly with cultural preferences, climate conditions, household size, expenditure, etc., and thus, should be determined locally. Moreover, such services should also be seen from the perspective of energy access objectives, types of carriers/technologies available, associated health and environmental hazards, adequate quality of supply, and at the minimum, fulfil cooking, heating and lighting requirements (Pachauri, 2011; Pachauri, et.al, 2004; Bazilian et.al, 2010a; Nussbaumer et.al, 2011; Pereira et.al, 2011; Practical Action, 2010).

A useful set of indicators with corresponding minimum standards for core energy services at the household, enterprise[2] and community level, were proposed by the Poor Peoples Energy Outlook 2010 report. These services, entitled total energy access (TEA), originally included cooking and water heating, space heating, lighting, cooling, information and communication technologies (ICTs) and earning a living, but gradually moved to only five basic energy services, excluding earning a living for the household level specifically (Practical Action, 2010; Practical Action, 2014). In addition, while insisting on the importance of energy services as a means to define energy access, the report also presented the supply oriented Energy Access Index, measuring quality of household fuels, electricity and mechanical power (Practical Action, 2010). Nevertheless, one should keep in mind that a lack of consensus on the basic energy needs persists. Hence, the above-mentioned energy services are just a suggested checklist, where, for instance, mobility is not yet included (Practical Action, 2010; Pachauri, 2011).

Barnes et. al. (2011), for example, complementing the quantifiable measure of energy poverty, introduced a new, demand-based approach to measure energy poverty in rural parts of Bangladesh. While examining the bond between household income and total and end-use energy consumption, and also considering household and community factors, the paper estimated the minimum level of energy consumption that remains constant regardless of income level. Using this approach, Barnes et. al. (2011) conclude that the energy poor are not necessarily income poor, and vice versa. Pachauri and Spreng (2011) have pointed out, however, that while accounting for all fuel types, households with high biomass consumption are considered as non-energy poor in the paper, thus omitting the health and safety issues of biomass use.

Few academic pieces have focused on the actual quality and reliability of energy carriers and appliances while estimating energy access. The reason for this lies in the difficulties associated with reliable data collection. While electricity data and research are considered to be comparatively available, other forms of energy and

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[2] Also known as “earning a living” level (Practical Action, 2014).

appliances are partially neglected in academic studies (Pachauri, 2011; Bazilian et.al, 2010b). Despite the lack of academic focus, unreliable and low quality energy carriers and appliances clearly cause many to rely on locally available and often inefficient energy sources, thus discouraging the uptake of modern energy and hindering socio-economic development (Pachauri, 2011; Barnes et.al, 2011; Pereira et.al, 2010; Bazilian et.al, 2010a).

In evidence, Pereira et. al. (2010) observed a positive correlation between access to reliable electricity supply and use of modern cooking fuels among rural households in Brazil, while Bazilian et. al. (2010b) identified both unreliable electricity services and involved costs as central components of energy security issues. It is noteworthy that regular and reliable access to electricity and modern fuels are of immense importance to rural dwellers. Underprivileged due to the high cost of grid expansion, sparse populations and limited capacity to pay, a number of targeted national policies and strategies and available off-grid solutions have targeted these rural communities (Pereira et.al, 2011; Barnes et.al, 2011; Kaygusuz, 2011; Rehman et.al, 2012; Pachauri et.al, 2004; Brew-Hammond, 2010).

As seen from the aforesaid, physical availability, adequacy, affordability, reliability, etc. are of equal importance when establishing energy access targets and defining energy poverty (Pachauri, 2011; Li et.al, 2013; Bazilian et.al, 2010a; Barnes et.al, 2011; Srivastava et.al, 2012; IEA, 2014). Furthermore, Pachauri (2011) states that in order to comprehensively define energy access, basic energy needs, quality and quantity of minimum energy services and associated modern energy costs versus household expenditure should be taken in consideration; thus, acknowledging the multidimensional nature of energy access and energy poverty.

In this regard, energy access and energy poverty can, therefore, be further quantified and assessed by measuring a combination of different indicators (Pachauri, 2011). In the literature, such measurement is defined as a composite index. Other available groupings include: single indicator, hinged on one certain dimension; set of individual indicators or “dashboard,” a number of independent indicators such as MDGs; and hybrid measurement, which combines both individual indicators and a composite index (Bazilian et.al, 2010a; Nussbaumer et.al, 2011).

Thus, Pachauri et. al. (2004), in their earlier work, presented a two-dimensional approach based on the example of India. This so called access-consumption matrix is able to capture both the energy distribution and energy poverty thresholds by taking into account access to/availability of different energy sources in the country and the quantity of useful energy consumed. Factors such as household size and use of non-commercial energy were also considered, while additionally estimating the energy poverty threshold. Consequently, the paper reveals that there is no statistically significant correlation between household expenditure and energy consumption on the condition that non-commercial energy is included in total energy use. What are clear, however, are the socio-economic benefits derived from the supply of clean and efficient energy services, such as electricity use that is not just restricted to cooking and heating, as well as the proximity of energy products (Pachauri et.al, 2004).

Mirza and Szirmai (2010), for instance, have developed a composite energy poverty index to assess the impact of seven different inconvenience indicators, such as health effects, children’s involvement, time spent, etc. with respect to the different energy sources, and energy shortfalls. Taking into account the household size for some of the indicators associated with inconvenience and adapting the per capita threshold energy requirements used for the Human Development Index (HDI), the study defines thresholds for both total inconvenience and energy shortfall experienced by rural households in Pakistan. It is important to note that natural gas was deliberately excluded from the investigated energy sources in order to better display the potential energy mix. Thus, in reaching the majority of the above-mentioned conclusions, the analysis also reveals that proximity or distance travelled to a specific energy source has a significant influence on household energy choice regardless of the income status. Firewood, however, despite the high level of household involvement in sourcing it, is expectedly the preferred source of energy for rural poor (Mirza/Szirmai, 2010).

At the international level, the most commonly used composite indicators are the HDI and the Energy Development Index (EDI). While the former identifies human development patterns, the latter measures developments in energy use in developing countries. Despite receiving heavy criticism in the literature, they provide a good platform to enable comparison between different countries and regions (Nussbaumer et.al, 2011; IEA, 2010; Pachauri/Spreng, 2011; Bazilian et.al, 2010a).

Nussbaumer et. al. (2011) have, so far, presented one of the most appropriate and comprehensive methodologies applicable to our empirical analysis, namely the Multi-dimensional Energy Poverty Index (MEPI), a composite index that can be compared over time and countries. Complementing the demand-side approach, and thus focusing on energy deprivation, the paper investigates the headcount and intensity ratio of energy poverty in 29 African countries, while later expanding the analysis to additional regions. Primarily aiming to evaluate access to modern energy services, the analysis further confirms an existing correlation between the findings and the HDI and EDI (Nussbaumer et.al, 2011; Nussbaumer et.al, 2013).

Providing valid results and applying a similar methodology to that of the Multidimensional Poverty Index (MPI) calculations, the MEPI, utilizing the academic research on multidimensional poverty measures, was only proposed by Nussbaumer et. al. (2011) in 2011 (Kovacevic/Calderon, 2014; Nussbaumer et.al, 2011). Despite being a relatively new approach, the MEPI has already been recognized by a number of other authors. Edoumiekumo et. al. (2013), Edoumiekumo/Karimo (2014) and Apere/Karimo (2014) have applied the MEPI to test the energy poverty situation in Nigeria; whereas Sher et. al. (2014) use it to assess energy poverty on the provincial level in Pakistan. Working with national surveys, the scholars adopted a variety of approaches to the assignment of weights and the threshold line below which households are considered non-energy poor.

Using the example of Nigeria and building upon the original MEPI methodology, we argue that the MEPI is an appropriate and valuable analysis tool for the investigation of energy poverty in selected countries of research. Further, we go beyond Nussbaumer et. al.’s MEPI approach and examine the influence of factors such as household composition and mobility on energy poverty; with the correlation of the above factors calculated and compared for all Nigerian states and regions. The dual life styles of rural and urban areas and the respective energy consumption patterns compared over time are also considered. Lastly, in order to reconfirm or reject the attainable findings, and thus, additionally provide policy makers with empirically solid results for improved decision-making, we turn to inferential statistics.

CHAPTER 2. Empirical Analysis

Utilizing the Multidimensional Energy Poverty Index (MEPI), this chapter focuses on capturing and assessing the diverse nature of energy deprivation in Nigeria and its variation across all the states and regions of the country, while simultaneously reporting on urban and rural discrepancies. We also analyze the selected individual indicators and, taking it a step further, investigate the potential impact of household composition, as well as mobility, on energy poverty.

Finally, in order to strengthen the attainable findings, while also minimizing the mono-method bias and verifying the MEPI results, a multiple regression analysis is conducted as the preferred method. This analysis will estimate the relationship between the energy deprivation score in Nigeria, a deprivation vector originally derived from the MEPI calculations, and other available explanatory indicators/variables that are deemed to be suitable for this research and consistent with the original five dimensions of the MEPI calculation proposed by Nussbaumer et. al. (2011).

The above-outlined analysis is calculated for three different nationally representative household surveys conducted in 2003, 2008 and 2013, respectively; thus, allowing an insight into energy poverty trends over time. Expecting to observe a positive trend in energy poverty elimination as a result of a shift toward more poverty-inclusive policies in recent years, we stress the need for the national government to pursue the consistent and effective implementation of existing and planned national policies and strategies aimed at ensuring the reliable, efficient and universal energy access.

2.1 Methodology

For the purposes of our analysis we have used the data of the Demographic and Health Surveys (DHS) conducted under a MEASURE DHS programme funded by the United States Agency for International Development (USAID). To ensure that the data is comparable across countries worldwide, the DHS has developed a standardized methodology in the form of three different questionnaires, namely for households, women and men, and collects information on a variety of topics, such as education, family planning, environmental health, wealth, household characteristics, etc. As the nationally representative household survey, the DHS also reports on a number of energy-related indicators, as well as background variables, for example, place of residence, regional location, etc. that additionally permits for subset analysis. Another advantage of the DHS is that the datasets are available in both raw and record/standardized data formats (www.dhsprogram.com; Rutstein/Rojas, 2006).

Specifically for Nigeria, there are five DHS available that were conducted during different time periods for each of the 6 geopolitical zones, 36 states and the Federal Capital Territory (FCT, Abuja); four of them are Standard DHS with an average sample size between 7,225 and 38,522 households[3]. The fifth, conducted in 2010, is a so called Malaria Indicator Survey (MIS), and while providing some relevant indicators for our analysis, is limited to only 5,895 households and thus, is excluded from the analysis. In addition, as the initial Standard DHS of 1990 also lacks the required information on the investigated variables, the forthcoming analysis is restricted to only three surveys, namely DHS-IV[4] for 2003, DHS-V for 2008 and DHS-VI for 2013 (www.dhsprogram.com).

Considering the multidimensional nature of energy poverty, we apply the MEPI, a consumption-based composite index proposed by Nussbaumer et. al. (2011), as the preferred method to determine the level of energy deprivation in Nigeria and to examine various variables and their relationships. The MEPI, comprised of five dimensions, namely cooking, lighting, services provided by means of household appliances (i.e. owning a fridge), entertainment/education and communication that are intended to represent the basic energy services required, consists of six corresponding indicators with assigned weights (see Table 1) (Nussbaumer et.al, 2011; Nussbaumer et.al, 2013).

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[3] In the 2013 DHS-VI a household was defined as "*a person or group of persons, related or unrelated, who usually live together in the same dwelling unit, have common cooking and eating arrangements, and acknowledge one adult member as the head of the household. A member of the household is any person who usually lives in the household*," (NPC/ICF International, 2014, p.11), which is consistent with previous definitions for the surveys DHS-V and DHS-IV (NPC/ICF Macro, 2009; NPC/ORC Macro, 2004).

[4] Roman numerals refer to the rounds/cycles of DHS surveys, which are normally conducted every 5 years.

Table 1: Dimensions and respective variables with cut-offs, including relative weights (in parentheses)

Dimension	**Indicator** *(weight)*	**Variable**	**Deprivation cut-off** *(poor if…)*
Cooking	Modern cooking fuel **(0.2)**	Type of cooking fuel	Use any fuel beside electricity, liquefied petroleum gas (LPG), kerosene, natural gas, or biogas
	Indoor pollution **(0.2)**	Food cooked on stove OR open fire (no hood/chimney) if using any fuel beside electricity, LPG, kerosene, 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 a radio OR television	False
Communication	Telecommunication **(0.13)**	Has a phone land line OR a mobile phone	False

Source: Nussbaumer et.al., 2011

Thus, in order to measure the MEPI, we firstly construct the survey matrix as:

$$Y = [y_{ij}] \tag{1}$$

Whereas: *i* represents the households across *j* indicators. Determined by whether the set of deprivation conditions specified in Table 1 are met or not, the value of 0 or 1, respectively, is assigned for the non-numerical data.

Secondly, while assigning the corresponding weights to the variables, we then calculate the deprivation score as:

$$h_i = \sum_j w_j y_{ij} \tag{2}$$

Whereas: h_i is the deprivation score of the i^{th} household and w_j is the variable weight specified in Table 1. In order to distinguish between the deprived and non-deprived households, we use the pre-defined cut-off k of 0.3. Therefore, households are considered energy poor when the computed sum h_i is greater than or equal to 0.3; whereas, when the computed sum h_i is less than 0.3, households are considered non-energy poor. Thus, the censored deprivation vector c_i can be written as:

$$c_i(k = 0.3) = \begin{cases} h_i: & h_i \geq 0.3 \\ 0: & h_i < 0.3 \end{cases} \tag{3}$$

The censored deprivation vector c_i allows us to further compute the total number q of energy poor, which takes into account the household size and sample weight of the specific survey entry, later referred to as adjustment vector a_i. This gives us the headcount ratio H of energy poor individuals with respect to the total number of individuals n as:

$$H = \frac{q}{n} \tag{4}$$

In turn, the intensity ratio of energy poverty A is calculated as the total sum of the adjusted deprivation vector $c_i a_i$ divided by the total number of energy poor q:

$$A = \frac{\sum_i c_i a_i}{q} \tag{5}$$

Finally, the MEPI, capturing both the headcount and intensity ratio of energy poverty, is defined as:

$$MEPI = H \times A \tag{6}$$

It is important to note that contrary to the work of Nussbaumer et.al. (2011, 2013), the missing data (e.g. not available, NA) for i households across j indicators is assigned the mean value of all available values and not a predefined default value with the intent to influence the data as little as possible. While the missing data could also be treated by removing NAs from the data frame, this approach would automatically remove the entire row as well and, therefore, reduce the sample size and alter the sample composition. Thus, use of the mean value, though causing some discrepancies, will prevent us from falsely assigning a positive value of 0 to NAs.

The routine used to conduct the aforementioned calculations via RStudio is presented in Appendix A.

2.2 Limitations

This empirical analysis will provide us with insights into the energy poverty situation in Nigeria, as well as in selected countries of the Sub-Saharan region, while quantifying the magnitude of incidence and intensity of the energy poverty. There are, however, caveats to this approach that need to be recognized. Firstly, the selected indicators purported to represent the scope of the households' end-use energy needs are indicative and restricted by a lack of reliable data. Thus, the indicators for space heating, cooling, and mechanical power, though of considerable importance, are not included in this analysis. Nevertheless, while noting the lack of common consensus on basic energy needs of an individual, the indicators included in this study are able to capture cooking and lighting requirements and are partially comparable with those proposed by the Poor Peoples Energy Outlook 2010 report. Furthermore, this study goes a step further by acknowledging the work of Sovacool et.al. (2012) and investigating the potential impact of mobility on energy poverty.

Secondly, aiming to assess access to modern energy services, while indirectly embracing the notion of affordability, this approach does not answer the question of quality and/or reliability of energy carriers and appliances due to limited data. Moreover, such valuable indicators as time spent and/or proximity to a specific energy source are also not captured in our analysis.

Finally, the above outlined weighting system was applied in our analysis for convenience and demonstration purposes; however, the subjective nature of this approach as described by Nussbaumer et. al. (2011) should be kept in mind. The uneven distribution of weights and assignment of 60% of the total weight for both cooking and lighting requirements reconfirms the conclusions of Nussbaumer et. al. (2011; 2013) in respect to the importance of these energy services for fulfilling basic energy needs as referred to in Chapter 1. Similarly, while subjectivity issues could be found in the use of the cut-off *k* of 0.3, the sensitivity analysis for the cut-off range of

0.2 - 0.4 was applied and tested across 29 African countries; revealing insignificant changes and validating the cut-off *k* of 0.3 (Nussbaumer et.al, 2013).

For illustration purposes, we further verify the impact of the suggested cut-off on the fluctuation of the computed deprivation score h_i for Nigeria (Fig.1).

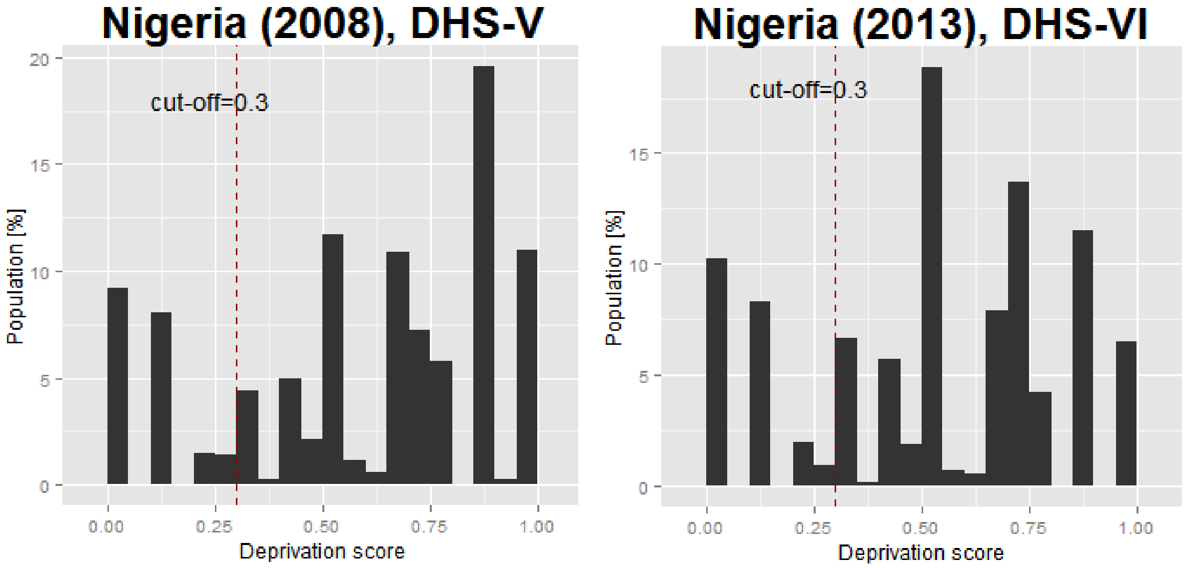

Figure 1: Deprivation distribution for different DHS for Nigeria

Source: Author's calculations derived from the Standard DHS data.

In principle, the MEPI is quite robust to changes in the cut-off; for instance, if the cut-off were set between 0.4 and 0.55, this would increase the intensity of energy poverty, in turn reducing the headcount ratio of energy poor and as a result, the MEPI would remain relatively unaffected by these manipulations. The results of two datasets for 2013 and 2008, as outlined in Figure 1, additionally reveal that the percentage of population situated in close proximity to the suggested cut-off is quite low and, therefore, would not significantly influence the headcount ratio of energy poor *H* and the intensity of energy poverty *A* regardless of the robustness of the MEPI.

2.3 Findings

Adopting the proposed threshold where an individual or country is, in general, deemed to experience an acute degree of energy poverty when the MEPI exceeds 0.9, and a low degree when the MEPI is less than 0.3 (Nussbaumer et.al, 2013), we establish the MEPI of 0.56 using the latest dataset available for Nigeria, thus classifying the country as one with a moderate degree of multidimensional energy poverty. The results also outline the headcount *H* and intensity *A* ratios of energy poor individuals as 0.8 and 0.7, respectively, whereas the total electricity rate for the country is equivalent to only 52.78%.

For comparison, we present the MEPI indicators for selected countries of the Sub-Saharan region, using the latest datasets available (Fig.2). The detailed results for the MEPI, and the headcount and intensity ratios of the energy poor individuals and their urban and rural discrepancy are further outlined in Appendix B.

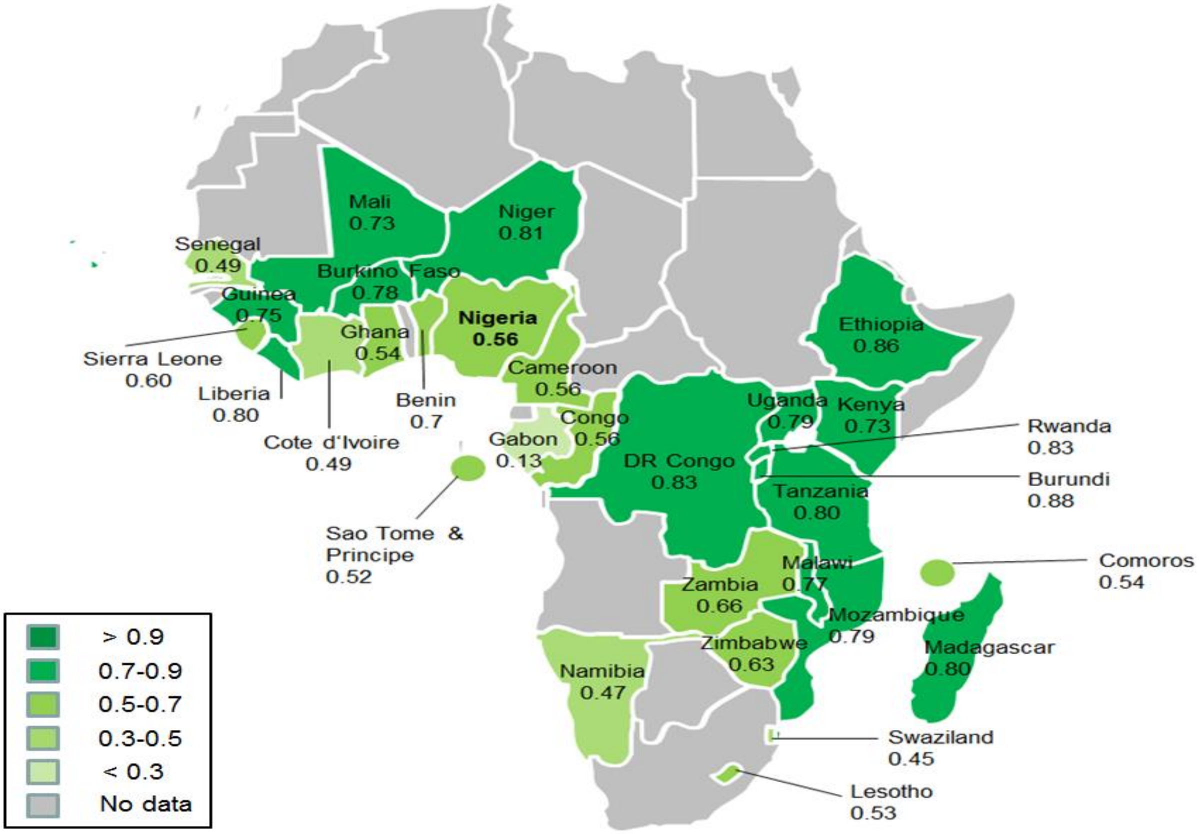

Figure 2: MEPI for selected countries of the Sub-Saharan region

Source: Author’s calculations derived from the Standard DHS data.

While such a comprehensive exercise provides a useful visual overview of the level of energy deprivation experienced in Sub-Saharan Africa and places Nigeria between the acute degree of energy poverty reported in Ethiopia and the low degree of energy poverty in Gabon, we should acknowledge that such a comparison is not completely representative. Employing the data of the latest Standard DHS available for each country, the MEPI was computed for different rounds/cycles of the Standard DHS that were conducted in different time periods (see App. B), while ideally it would be more accurate to compare the MEPI results of the same time intervals.

Moreover, due to the lack of data available for some of the variables, we were required to come up with the most appropriate solution to calculate the MEPI, while minimizing the possible distortion of the results; thereby applying different calculation techniques for different countries. As mentioned above, the mean values of all available values were assigned to NAs, whereas the variable was completely removed if the data was not available for the entire row. As shown in Appendix C, the bulk of unavailable data relates to the “indoor pollution” indicator that is comprised of three different variables and refers to the cooking dimension. Thus, in accordance with the work of Nussbaumer et. al. (2013), the “indoor pollution” indicator was deleted when the data for at least two variables was 100% unavailable, while the weight of 0.2 was reassigned to the “modern cooking fuel” indicator accordingly. In the case where the data was unavailable for only one variable (e.g. Household has a chimney, hood or neither) under a certain indicator, the variable was removed without further deleting the entire indicator.

Considering that this study is fully devoted to Nigeria and aims at providing an insight into energy poverty trends over time, among other parameters, we have examined the data availability for all three Standard DHS that are thought to be appropriate for our analysis. Unfortunately, the complete set of data is available only for the survey conducted in 2008; whereas both DHS-IV for 2003 and DHS-VI for 2013 are lacking some data. If, as in the case of DHS-IV for 2003, the data is unavailable for all three variables under the “indoor pollution” indicator, it was deemed necessary to exclude the indicator and adjust the weighting system; DHS-VI for 2013, however, lacks data for only two variables under the “indoor pollution” indicator (see App. C). As specified in Table 1, the calculations for the cooking dimension is structured in such a way that the “indoor pollution” indicator is computed only when the individual and/or household is using inefficient types of cooking fuels (i.e. any fuel besides electricity, LPG, kerosene, natural gas, or biogas) with the intention of reducing the deprivation score h_i if at least the health hazards, associated with the use of the particular stove type, are addressed. Thus, the aforementioned gives us the foundation to assume that even with one variable available, the “indoor pollution” indicator could still theoretically provide valid computations.

For this reason, we have tested this proposed assumption only for those countries with the complete set of data, with the intention to establish a consistent technique for data treatment and display any possible distortion (see Table 2).

Table 2: Sensitivity analysis on missing data treatment

Country	**Scenario 1:** Results with all indicators			**Scenario 2:** Results without HV239[5] and HV240			**Scenario 3:** Results without HV239, HV240 and HV241		
	H	**A**	**MEPI**	**H**	**A**	**MEPI**	**H**	**A**	**MEPI**
Nigeria, VI / 2013	-	-	-	0.78	0.66	0.51	0.80	0.7	0.56
Nigeria, V / 2008	0.79	0.71	0.56	0.80	0.72	0.57	0.81	0.75	0.61
Cameroon	0.81	0.68	0.56	0.81	0.68	0.56	0.84	0.73	0.61
Cote d'Ivoire	0.82	0.60	0.49	0.82	0.60	0.49	0.86	0.69	0.59
Lesotho	0.84	0.64	0.53	0.84	0.64	0.54	0.84	0.75	0.63
Madagascar	0.98	0.81	0.80	0.99	0.82	0.81	0.99	0.85	0.84
Malawi	0.97	0.79	0.77	0.97	0.80	0.78	0.98	0.85	0.84
Sierra Leone	0.94	0.64	0.60	0.97	0.70	0.68	1	0.80	0.80
Zambia	0.83	0.79	0.66	0.83	0.79	0.66	0.84	0.87	0.74

Source: Author's calculations derived from the Standard DHS data.

As expected, the disparity in the MEPI score between the first and second scenarios, observed in Table 2, varies from 1 to 2%, and only in the case of Sierra Leone accounts for approximately 13%. In turn, the disparity between the first and third scenarios is much greater, ranging between 9% and 20%, with 33% for Sierra Leone. Thus, acknowledging the existing bias and constraints of these simulation techniques, we apply the second scenario as the best possible approach to compute the MEPI for DHS-VI 2013 for Nigeria.

2.3.1 Trend over Time Analysis of Nigeria

Before proceeding further, it is important to note that in light of the high discrepancy in the MEPI score between the first and third scenarios, as shown in Table 2, we recognize the inaccuracy in comparing the MEPI results for DHS-IV 2003 with those of DHS-V 2008 and DHS-VI 2013, and thus have excluded DHS-IV 2003 from the

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[5] HV239, HV240 and HV241 refer to the codes of the variables used in the DHS and described in Appendix C.

majority of the MEPI calculations. Despite this fact, where possible and/or useful, the information for DHS-IV 2003 will be utilized throughout the study.

Keeping in mind the aforesaid, we set the trend line to indicate the changes in the MEPI, as well as the headcount ratio *H* of energy poor and intensity of energy poverty *A*, between 2003 and 2013 in Nigeria (see Fig.3).

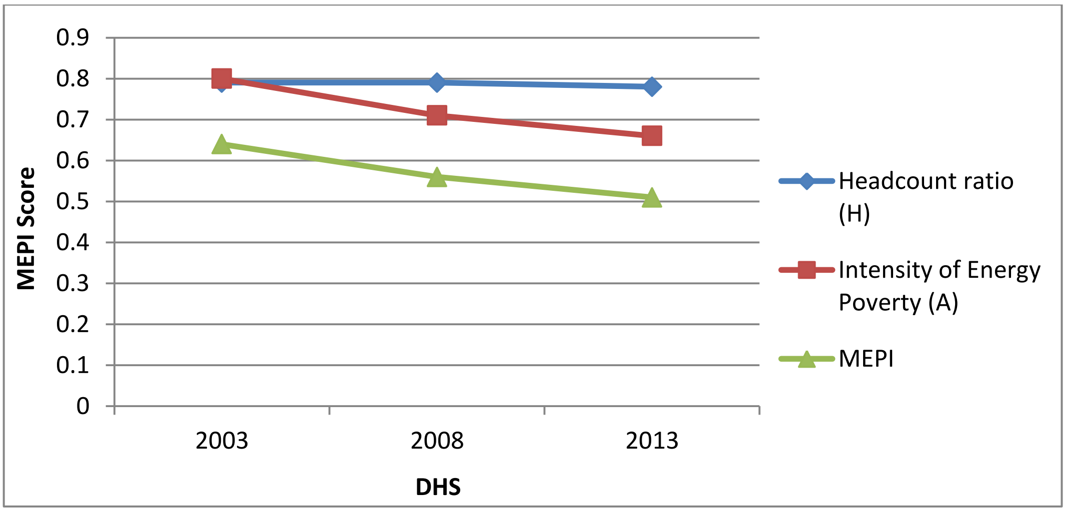

Figure 3: Trend over time analysis of the MEPI for Nigeria

Source: Author's calculations derived from the Standard DHS data.

The trend observed in Figure 3 indicates a progressive improvement in the MEPI attributed to the decline in energy poverty intensity, whereas the headcount ratio of energy poor still remains relatively constant. This implies that the country's efforts in expanding energy access to mitigate energy poverty, though positive, are insufficient in the face of rapid population growth. Moreover, it also implies that as compared to 2003, a large share of the population has greater access to cleaner and efficient energy services in 2013.

While not completely accurate due to the distortive effect of the cut-off *k* and missing data (e.g. not available, NA), Figure 4 additionally illustrates the representation of the six indicators[6] and corresponding variables, described in Table 1, and their influence on the deprivation score h_i for Nigeria and thus, the overall MEPI calculation. As expected, the indicator for modern cooking fuels has the largest influence on h_i, constituting 26% and 29% for 2008 and 2013, respectively. The household appliance own-

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[6] Please note that due to the reasons explained in section 2.3 the "Indoor pollution" indicator for DHS-VI 2013 consists only of one variable instead of three.

ership (i.e. owning a fridge) indicator, surprisingly, is placed second, whereas electricity access and indoor pollution indicators have an almost identical impact on the MEPI results.

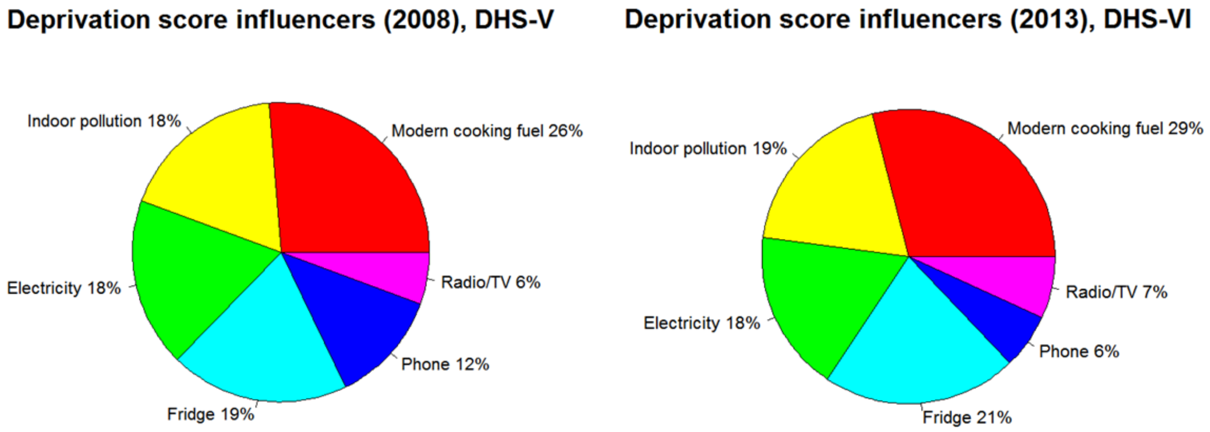

Figure 4: Deprivation score influencers for different DHS for Nigeria

Source: Author’s calculations derived from the Standard DHS data.

To delve deeper into the circumstances of energy deprivation in Nigeria, while at the same time affirming that rural dwellers are commonly those suffering from a higher degree of energy deprivation, we further provide a detailed analysis of the existing discrepancy between urban and rural parts of the country. Additionally, we attempt to shed light on energy poverty distribution across all Nigerian states and geopolitical zones, as well as offer insight into electricity rates and the cooking fuel preferences of local households. This complementary analysis aims at accurately capturing and assessing energy poverty in the country, while simultaneously avoiding a generalization of the results.

As seen from Figure 5 below, rural communities are, indeed, considered to be underprivileged and lagging behind in all parameters as compared to those in urban areas. On average, the MEPI varies between 0.32 and 0.71 in urban and rural areas, respectively, corresponding to a 55% discrepancy. Electricity rates are also unmerciful, accounting for only 32.76% in rural parts of the country in 2013 (see Fig. 6). While the share of population with access to electricity remains relatively constant over time for both rural and urban populations, a notable finding is the illogical electricity rates results between DHS-IV 2003 and DHS-V 2008 that can be explained by either unjust data treatment or independent factors, such as social and political unrest, poor maintenance of power plant facilities, etc. in 2008 (EIU, 2008).

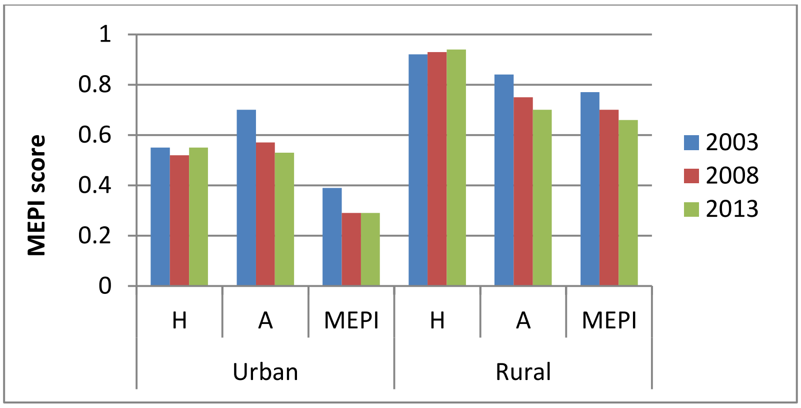

Figure 5: Trend over time analysis of the MEPI for Nigeria: urban vs. rural poor
Source: Author's calculations derived from the Standard DHS data.

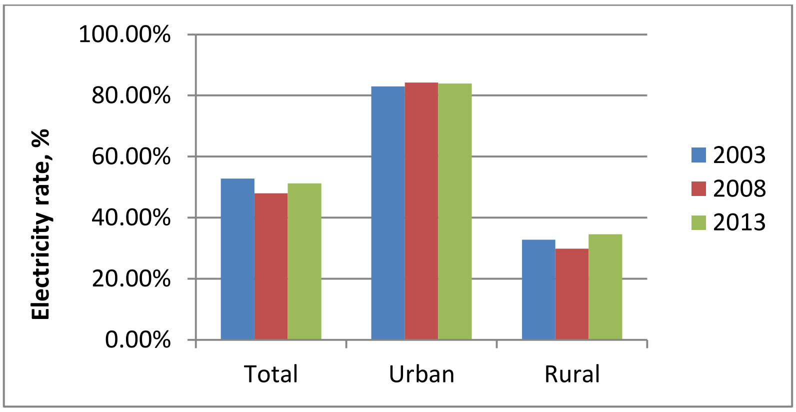

Figure 6: Electricity rates over time for Nigeria: urban vs. rural
Source: Author's calculations derived from the Standard DHS data.

For more details and the routine used for electricity calculations, please refer to Appendices A and D.

The detailed analysis of the six geopolitical zones of Nigeria, presented in Appendix E, reveals that only the South West region, comprised of the Oyo, Ogun, Osun, Ekiti and Lagos states, has a low degree of energy poverty. The North East region, to the contrary, is considered to be the most energy deprived, accounting for both the highest headcount ratio *H* of energy poor individuals and overall intensity of energy poverty *A*. In general, the southern part of the country is recognized as being more advanced in securing energy access than its northern neighbor.

To further highlight the wide variation of energy poverty across urban and rural communities, we have computed the MEPI for all Nigerian states based on the 2013 data, and summarized the most valuable results in Table 3, while the complete set of results is presented in Appendix F.

Table 3: MEPI at state levels for DHS-VI 2013 for Nigeria

States	Urban				Rural			
	H	**A**	**MEPI**	**Electricity rate**	**H**	**A**	**MEPI**	**Electricity rate**
Yobe	0.95	0.52	0.5	85.23%	1	0.74	0.74	0.39%
Gombe	0.95	0.6	0.57	77.15%	1	0.76	0.75	36.44%
Bauchi	0.97	0.54	0.53	83.87%	1	0.77	0.77	23.31%
Niger	0.72	0.45	0.32	99.91%	0.98	0.66	0.65	42.02%
Abuja	0.15	0.42	0.06	93.20%	0.82	0.58	0.47	41.28%
Taraba	0.72	0.63	0.45	48.33%	1	0.78	0.78	2.24%
Ekiti	0.48	0.47	0.23	92.80%	0.72	0.46	0.33	94.17%
Ebonyi	0.92	0.58	0.54	34.65%	0.69	0.58	0.4	61.20%
Imo	0.72	0.56	0.4	66.78%	0.7	0.56	0.39	73.36%
Rivers	0.18	0.42	0.07	90.27%	0.89	0.62	0.55	46.31%
Bayelsa	0.38	0.56	0.21	77.11%	0.65	0.58	0.38	38.88%
Lagos	0.08	0.44	0.04	99.48%	-	-	-	-

Source: Author's calculations derived from the Standard DHS data.

On top of the obvious discrepancy between the urban and rural populations, there is evidence of substantial variation, often rendered invisible in official statistics, at the state level. For instance, while Lagos state has the highest electricity rate and as a result, a low degree of energy poverty as compared to the rest of the country, Taraba state accounts for the lowest level of electricity rates among urban populations, and only 0.39% electricity access is reported in rural parts of Yobe state. An unforeseen outcome of the MEPI calculations of this study was recorded for the Ebonyi and Imo states. Both situated in the South East region of Nigeria, they score high for electricity access, as well as a low headcount ratio of energy poor in rural areas, as compared to those in urban areas. While such outcomes could stem from a variety of reasons that ideally should be explored further, we consider this beyond the scope of our paper and thus, an exception rather than the rule. Moreover, while the results of these calculations might be useful for future energy policy formulations, it should be noted that neither the MEPI nor measured electricity rates provide a clear picture of the actual quality and reliability of energy carriers and appliances in Nigeria.

Finally, we offer additional insight into cooking fuel preferences of Nigerian households demonstrated in Figure 7.

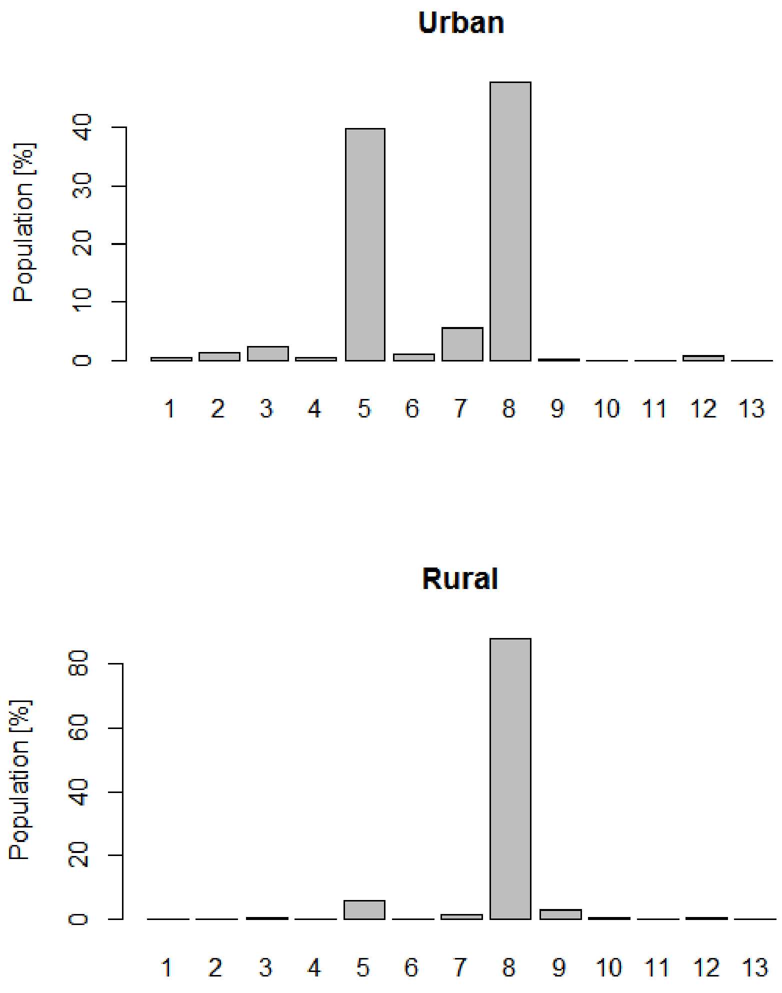

Figure 7: Use of cooking fuels in Nigeria, 2013

Note: [1] electricity; [2] LPG; [3] natural gas; [4] biogas; [5] kerosene; [6] coal, lignite; [7] charcoal; [8] wood; [9] straw/shrubs/grass; [10] agricultural crop; [11] animal dung; [12] no food cooked in household; [13] other.

Source: Author's calculations derived from the Standard DHS data.

Figure 7 reconfirms a well-established fact that energy poverty is associated with a strong reliance on traditional use of biomass (IEA, 2014; Sovacool et. al, 2012). Regardless of the household's place of residence, wood was recorded as the preferred source of energy for cooking in Nigeria in 2013; whereas kerosene, placed second, was more broadly used in urban communities. Similarly, modern fuels such as electricity, LPG, natural gas, and biogas, though insignificant within the total energy fuel mix, prevailed in urban areas, which is in line with the above-mentioned MEPI results tested for urban and rural discrepancy. Moreover, while cooking fuel preferences of Nigerian households remain unchanged for the most part, compared to the results of 2008 (see App. G), a positive trend in the use of LPG and charcoal has been identified, as well as a slight decline in the use of kerosene in urban communities. To the contrary, in the case of rural communities, an increase in the use of straw, shrubs and grass, as well as a decline in the use of kerosene, were observed in 2013 as compared to 2008. Though we suspect that these minor changes could simply be attributed to the issue of accessibility of energy products in the rural areas (IEA, 2014), the government's unsuccessful efforts to eliminate fuel subsidies in 2012 (Schiere, 2012) could also be considered a potential cause.

2.3.2 MEPI vs. Wealth Index

Since the survey permits a subset analysis, we further recalculate the MEPI based on wealth distribution (see Fig. 8); while additionally demonstrating the electricity rates for different wealth categories in Nigeria (see App. H).

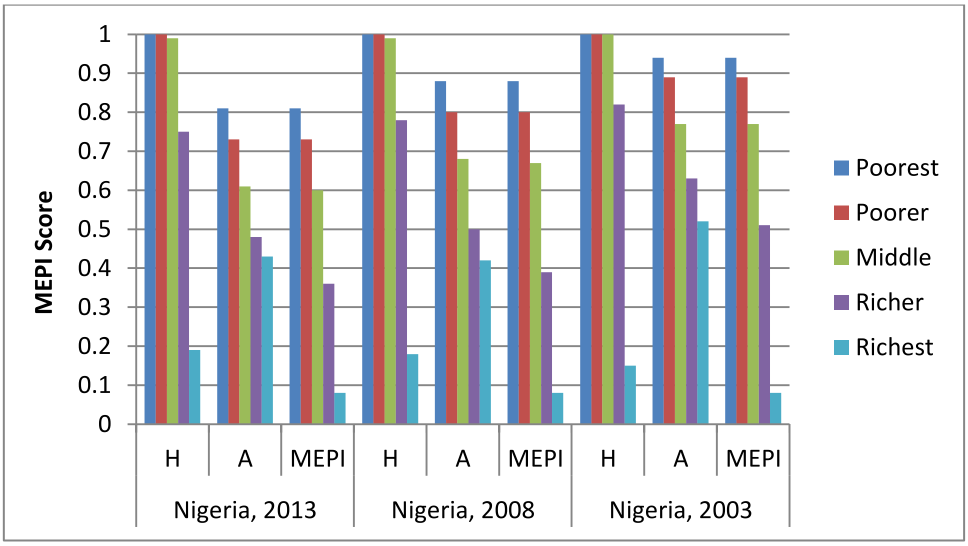

Figure 8: MEPI based on wealth index for various Standard DHS for Nigeria

Source: Author's calculations derived from the Standard DHS data.

With the exception of the results for the richest class that remain relatively unchanged, Figure 8 reveals slight improvements in the MEPI over time attributed to the decline in energy poverty intensity, as well as an uneven distribution of energy poverty between the poorest and richest classes in Nigeria meaning that while the richest class experiences a low level of energy poverty, the poorest remain slightly below an acute level of energy poverty. Furthermore, a clear correlation between the level of electricity access and the MEPI based on wealth distribution was also observed, supporting the work of Pereira et. al. (2011) that based on the example of rural households in Brazil suggests that an increase in access to electricity alleviates energy poverty and inequality. This additional analysis provides a clear picture of the ineffectiveness of government efforts to expand and/or improve energy access to the poorest groups in Nigeria.

2.3.3 MEPI and the Potential Impact of Household Composition

Recognizing the importance of household composition on energy poverty, as highlighted by Mirza/Szirmai (2010) and Pachauri et. al. (2004), we assess two variables, namely sex of head of household and number of children[7] in household that are available in DHS and are deemed relevant for our analysis.

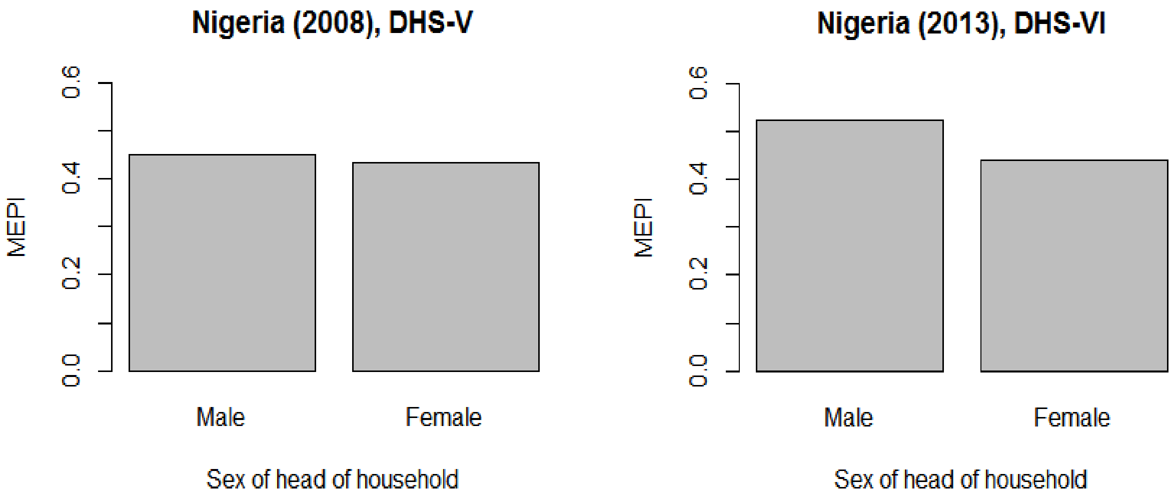

Figure 9: MEPI vs. sex of head of household

Source: Author’s calculations derived from the Standard DHS data.

Though, as seen from Figure 9, the difference in the MEPI does not exceed 18% between households headed by females as compared to male headed ones, it still displays lower levels of energy deprivation for female headed households. These findings could be attributed to the fact that both cooking, as well as firewood collection, is normally the responsibility of women, and as they are particularly vulnerable, are more aware of the health and safety issues arising from the use of inefficient and

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[7] Children are defined as those being 5 years old or under.

harmful means for cooking. This gives us reason to believe that further awareness raising, as well as women's empowerment, could have a positive effect on combating energy poverty in the country (Mirza/Szirmai, 2010; Barnes et. al, 2011; Li et. al, 2013; Sovacool et. al, 2012; IEA, 2014; Heltberg, 2003). Moreover, despite being controversial by nature, it would also be interesting to investigate the overall impact of the number of women with complete primary and/or secondary education on the MEPI results. Unfortunately, the data available does not permit such manipulations and hence, we leave this for future analysis.

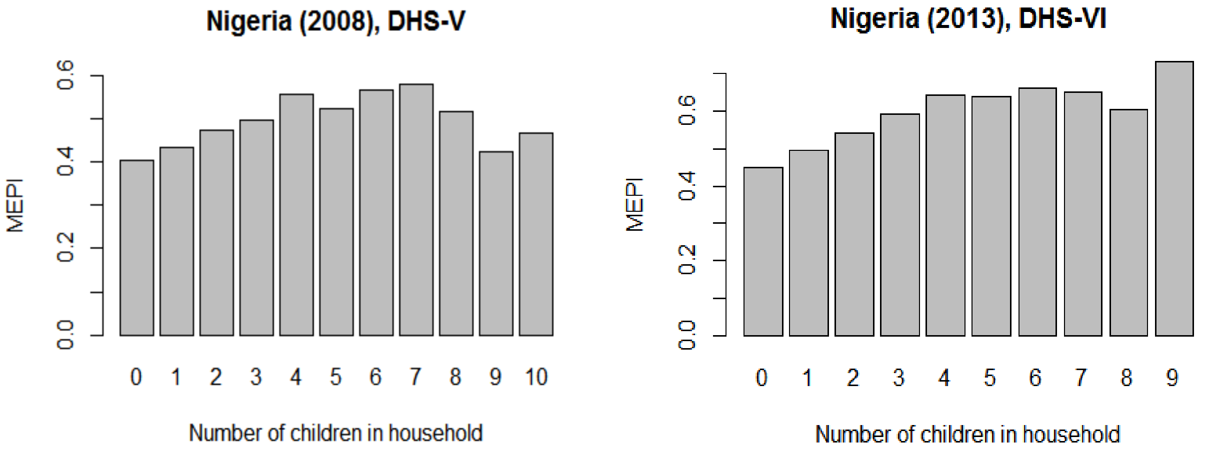

Figure 10: MEPI vs. number of children in household

Source: Author's calculations derived from the Standard DHS data.

Further, while expecting that the incremental increase in adults per household would more significantly influence an increase in the MEPI than the incremental increase of children, and thus, reconfirm the assumption of Pachauri et. al. (2004) that the amount of energy required for cooking needs should correlate with household composition, we were unable to prove or disprove these assumptions due to lack of corresponding data. Nevertheless, though the results of Figure 10 are not so pertinent and only confirm the expected, they still, at the minimum, reveal the scale effect exerted by the number of young children present in household.

2.3.4 Impact of Mobility on Energy Poverty Content

Finally, acknowledging the work of Mirza/Szirmai (2010) and the suggestion of Sovacool et. al. (2012) to include mobility alongside other energy services, such as lighting, heating and cooking, this study tests the impact of mobility on the level of energy deprivation with the aim to further reconfirm the complex and diverse nature of energy deprivation.

To do so, we examine the number of transport modes available and owned by households, such as bicycles, motorcycles/scooters, cars/trucks, animal-drawn carts and boats with a motor, under the assumption that an increase in the number of transport modes available will ensure convenient access to the required energy sources and thus, would decrease the MEPI. Moreover, this comparison could indirectly embrace and support the conclusions made in the work of Mirza/Szirmai (2010).

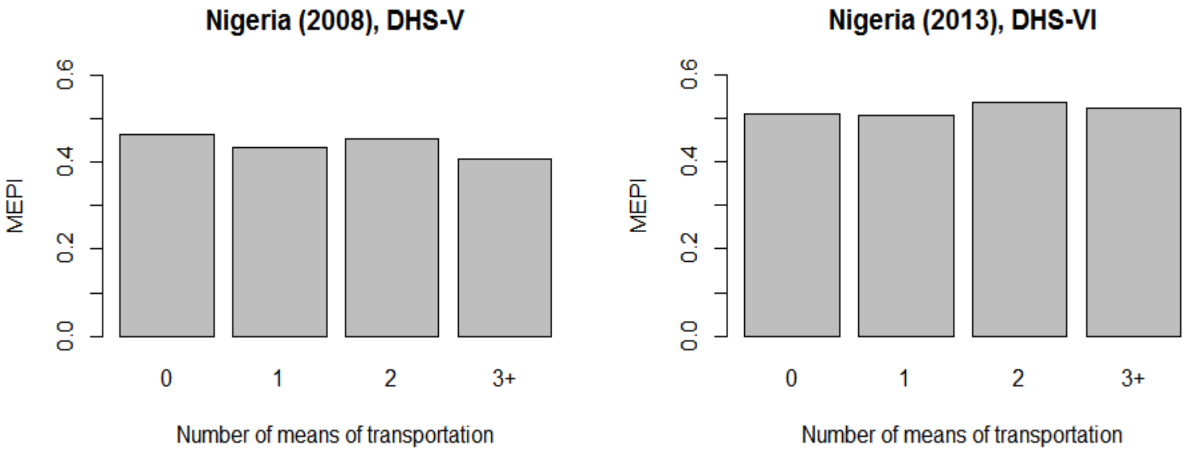

Figure 11: MEPI vs. number of means of transport

Source: Author’s calculations derived from the Standard DHS data.

As seen from Figure 11, the relationship between the MEPI and mobility was proven to be insignificant. While there is a minor decrease in the MEPI as a result of an increase in the number of transport modes available in 2008, this trend was not reconfirmed for 2013. In general, more than 50% of the respondents reported an absence of any kind of transportation owned, with less than 2% having 3 or more means of transportation, for both datasets. In our opinion, there could be two possible explanations for this outcome; firstly, there is simply no direct influence of mobility on the alleviation of energy poverty and secondly, which is more likely, mobility should rather be incorporated within the MEPI calculations, instead of being seen as a separate indicator.

2.4 Multiple regression analysis

With the aim to further provide policy makers with empirically solid results for improved decision-making, we turn to inferential statistics; this serves to strengthen the above findings, i.e. the potential influence of household composition and mobility on energy poverty, and wide variation of energy poverty observed across the country's geopolitical zones, place of residence and wealth categories, while also minimizing the mono-method bias and verifying our MEPI results. Multiple regression analysis has been chosen as the preferred method to estimate the relationship between the energy deprivation score in Nigeria and other available indicators in two datasets for 2013 and 2008 that are deemed to be suitable and aligned with the original variables presented in Table 1.

Mathematically, the multiple regression function can be illustrated as below:

$$h_i = \beta_1 + \beta_2 x_{2i} + \beta_3 x_{3i} + \cdots + \beta_n x_{ni} + u_i \quad (7)$$

Whereas: h_i is the dependent variable that represents the deprivation score as explained in equation (2) prior to the introduction of the cut-off, X_2 and X_n are the independent or explanatory variables, and u_i is the stochastic disturbance term of the i^{th} household. β_1 represents the intercept, while β_2, β_3, …, β_n are the partial slope coefficients.

It should be noted that in our case the residuals are weighted, namely the sample weight of the specific survey entry was taken into account for β calculations. Thus, we apply the weighted least squares (WLS) method; a special occurrence of the generalized least squares (GLS) method, for the forthcoming regression analysis. Algebraically, the weighted sum of residual squares (RSS) $\sum w_i \hat{u}_i^2$ can be written as follows:

$$min \sum w_i \hat{u}_i^2 = \sum w_i \left(h_i - \hat{\beta}_1 - \hat{\beta}_2 x_{2i} - \hat{\beta}_3 x_{3i} - \cdots - \hat{\beta}_n x_{ni}\right)^2 \quad (8)$$

Whereas: w_i is the sample weight and $\hat{u}_i^2$ is the residual of the i^{th} household. $\hat{\beta}_1$, $\hat{\beta}_2$, …, $\hat{\beta}_n$ are estimators of β_1, β_2, …, β_n.

Following the two-tail procedure and fixing the significance level *α* at 0.05 (5%) as the minimum threshold for this research, we state the null *(H_0)* and alternative *(H_1)*

hypotheses to test any individual partial regression coefficient as:

$$\begin{array}{ll} H_0:\ \beta_2 = 0 & H_1:\ \beta_2 \neq 0 \\ \qquad \beta_3 = 0 & \qquad \beta_2 \neq 0 \\ \qquad \ldots & \qquad \ldots \\ \qquad \beta_n = 0 & \qquad \beta_n \neq 0 \end{array} \tag{9}$$

and, overall significance of the multiple regression model as:

$$H_0:\ \beta_1 = \beta_2 = \ldots = \beta_n = 0 \qquad H_1:\ \text{otherwise}^{8} \tag{10}$$

The hypothesis specified in equation (9), with the help of a *t* test, aims to shed light on the individual significance of each partial regression coefficient in the model; whereas with the help of the *F* test, the hypothesis in equation (10) will reveal whether the entire set of independent variables simultaneously contribute significantly to the prediction of the energy deprivation score h_i in Nigeria.

Thus, using the data of the DHS described in section 2.1 of this paper, with the predetermined sample size of 38,522 and 34,070 households for DHS-VI for 2013 and DHS-V for 2008, respectively, we have identified 20 indicators to serve as the independent variables for this multiple regression analysis. These indicators/variables, aside from being chosen based on their availability in the datasets and providing consistency with the five dimensions of the MEPI calculation proposed by Nussbaumer et. al. (2011), also include some of those variables investigated above in order to reconfirm or reject their impact on energy poverty. In addition, we have included two new indicators, namely “owns livestock, herds or farm animals” and “owns land usable for agriculture,” to examine the hypothesis of Mirza/Szirma (2010) that rural landlords and households with livestock ownership are less energy deprived, using the example of Nigeria.

Firstly, conducting the stepwise backward regression to drop the irrelevant variables and hence, determine the accurate selection of the independent variables for the model (see App. I), a total of 18 variables were selected and are presented below.

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[8] Alternatively, H_1 can be stated as *“Not all slope coefficients are simultaneously zero”* (Gujarati/Porter, 2009, p.240).

Table 4: Independent variables of the multiple regression analysis

Variable	Variable type	Explanation	Omitted category
		General information	
Region	Nominal	Region (North Central; North East; North West; South East; South South; South West)	North Central
Residence	Dichotomous	Type of place of residence (urban/rural)	Urban type of residence
Wealth	Ordinal	Wealth index (poorest; poorer; middle; richer; richest)	Poorest
		Household composition	
Gender	Dichotomous	Sex of head of household	Male
HV009[9]	Numeric	Number of household members	-
HV014[9]	Numeric	Number of children 5 and under (de jure)	-
HV220	Numeric	Age of head of household	-
		Mobility	
Animal-drawn cart	Dichotomous	Has animal-drawn cart	Has none
Bicycle	Dichotomous	Has bicycle	Has none
Motorcycle/scooter	Dichotomous	Has motorcycle/scooter	Has none
		Livestock and land ownership	
Livestock	Dichotomous	Owns livestock, herds or farm animals	Has none
Own land	Dichotomous	Owns land usable for agriculture	Has none
		Household appliance ownership	
Air conditioner	Dichotomous	Has air conditioner	Has none
Electric iron	Dichotomous	Has electric iron	Has none
Fan	Dichotomous	Has fan	Has none
Generating set	Dichotomous	Has generating set	Has none
		Entertainment/education appliance ownership	
Cable TV	Dichotomous	Has cable TV	Has none
Computer	Dichotomous	Has computer	Has none

Source: Author's selected variables sourced from the Standard DHS data

As outlined in Table 4, the explanatory variables are conditionally grouped within 6 categories, namely: general information, household composition, mobility, livestock and land ownership, household appliance ownership and entertainment/education

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[9] Please note that variable HV009 was used only for multiple regression analysis of DHS-VI 2013, and variable HV014 used only for multiple regression analysis of DHS-V 2008.

appliance ownership. Moreover, as seen from the above, only a few variables are nominal, ordinal and numeric, with the majority of the variables being dichotomous by nature. The dichotomous variables are nominal scale variables and thus, to establish the dummy variables for the regression analysis, the values of 1 and 0 were ascribed for the non-numerical data to indicate the positive (e.g. has air conditioner) and negative responses of the households, respectively. In the case of the gender variable, a value of 1 represents female; whereas for the residence variable, 1 represents rural type of residence. To avoid perfect multicollinearity, the rule by which *"the number of dummy variables introduced must be one less than the categories of that variable"* (Gujarati/Porter, 2009, p. 281) or *(m-1)*, was also applied (see Table 4).

Secondly, bypassing the descriptive statistics that are described in detail in the final reports for DHS-VI 2013 and DHS-V 2008, namely NPC/ICF International (2014) and NPC/ICF Macro (2008), we, nonetheless, briefly take up the issue of the NAs for *i* households across independent variables for the forthcoming analysis. The missing data was treated by removing NAs from the data frame, thereby automatically causing the removal of entire rows and reducing the sample size to a total of 37,957 households for DHS-VI 2013 and 33,586 households for DHS-V 2008. The percentage of NAs for each independent variable is outlined in Appendix J.

Finally, considering the assumptions of the multiple regression model, we can conclude that due to the large sample size available for both datasets and the nature of data used, namely cross-sectional data[10], we can relax the assumption of normal distribution of the stochastic disturbance term $u_{i.}$ Similarly, the assumption of autocorrelation can be relaxed as for this study, households are considered to be cross-sectional units and therefore, there is no prior reason to expect a correlation between the disturbances. The assumption on data, namely *"the number of observations n must be greater than the number of parameters to be estimated"* (Gujarati/Porter, 2009, p.315) has been fulfilled based on the number of independent variables described in Table 4 and the sample size; whereas the results of the multicollinearity test, outlined in Appendix K, are considered to be acceptable as the generalized variance-inflating factor (GVIF) does not exceed 10. Lastly, as heteroscedasticity is typical for such data types, it has been considered in Appendix L

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[10] Defined as *„data collected at one point in time"* (Gujarati/Porter, 2009, p.21).

(Gujarati/Porter, 2009).

Table 5: Results of the multiple regression analysis – DHS-VI 2013

	No region	**Region**	**No region / no gender**[11]	**Region / gender**[11]
Intercept	7.358e-01***	7.335e-01***	0.7360569***	7.337e-01***
Region **NE**	-	4.354e-02***	-	-
Region **NW**	-	-4.864e-03.	-	-
Region **SE**	-	-5.109e-02***	-	-
Region **SS**	-	-6.523e-02***	-	-
Region **SW**	-	-9.906e-02***	-	-
Region **NE female**	-	-	-	1.054e-01***
Region **NW female**	-	-	-	4.067e-02***
Region **SE female**	-	-	-	1.439e-02***
Region **SS female**	-	-	-	**8.008e-04**
Region **SW female**	-	-	-	-6.055e-02***
Residence	3.841e-02***	3.628e-02***	0.0383556***	3.808e-02***
Wealth **Poorer**	-7.407e-02***	-6.138e-02***	-0.0738077***	-7.323e-02***
Wealth **Middle**	-1.970e-01***	-1.680e-01***	-0.1965568***	-1.932e-01***
Wealth **Richer**	-3.777e-01***	-3.319e-01***	-0.3771705***	-3.704e-01***
Wealth **Richest**	-5.939e-01***	-5.296e-01***	-0.5934570***	-5.845e-01***
Gender	**2.887e-03**	**1.446e-02**	-	-
# of household members	**3.022e-04**	-9.104e-04**	**0.0002432**	**1.722e-04**
Age	6.665e-04***	9.638e-04***	0.0006779***	7.181e-04***
Animal-drawn cart	-1.329e-02**	-2.646e-02***	-0.0133169**	-1.261e-02**
Bicycle	**-4.708e-04**	-6.021e-03**	**-0.0005660**	**-1.674e-03**
Motorcycle/scooter	**-1.218e-03**	-6.964e-03***	**-0.0015780**	-3.163e-03.
Livestock	-4.768e-03*	-9.569e-03***	-0.0047086*	**-3.334e-03**
Own land	2.812e-02***	2.574e-02***	0.0279132***	2.551e-02***
Air conditioner	-4.944e-02***	-5.091e-02***	-0.0495357***	-5.066e-02***
Electric iron	-1.551e-02***	-1.681e-02***	-0.0156059***	-1.655e-02***
Fan	-5.633e-02***	-5.751e-02***	-0.0564171***	-5.644e-02***
Generating set	3.127e-02***	3.581e-02***	0.0311820***	2.961e-02***
Cable TV	-1.469e-02***	-3.548e-02***	-0.0147707***	-1.965e-02***
Computer	-1.592e-02***	-2.060e-02***	-0.0159477***	-1.689e-02***
R^2	0.7375	0.753	0.7375	0.7412
Adjusted R^2	0.7374	0.7528	0.7374	0.7411
F-statistic	^{5609}(19,37937)	^{4817}(24,37932)	^{5921}(18,37938)	^{4724}(24,37933)
p-value	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Source: Author’s calculations derived from the Standard DHS data.

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[11] The columns entitled “no region / no gender” and “region / gender” combine both region and gender variables to additionally showcase the relationship of sex of head of household, 6 regions, and energy deprivation score in Nigeria.

Table 6: Results of the multiple regression analysis – DHS-V 2008

	No region	**Region**	**No region / no gender**	**Region / gender**
Intercept	7.487e-01***	7.497e-01***	7.516e-01***	7.487e-01***
Region **NE**	-	5.642e-03.	-	-
Region **NW**	-	1.079e-02***	-	-
Region **SE**	-	-1.494e-02***	-	-
Region **SS**	-	-1.519e-02***	-	-
Region **SW**	-	-5.497e-02***	-	-
Region **NE female**	-	-	-	3.665e-02***
Region **NW female**	-	-	-	3.685e-02***
Region **SE female**	-	-	-	2.588e-02***
Region **SS female**	-	-	-	3.777e-02***
Region **SW female**	-	-	-	-1.503e-02***
Residence	3.374e-02***	3.427e-02***	3.428e-02***	3.273e-02***
Wealth **Poorer**	-7.362e-02***	-6.548e-02***	-7.199e-02***	-7.259e-02***
Wealth **Middle**	-1.897e-01***	-1.764e-01***	-1.865e-01***	-1.879e-01***
Wealth **Richer**	-4.218e-01***	-4.003e-01***	-4.185e-01***	-4.193e-01***
Wealth **Richest**	-6.642e-01***	-6.322e-01***	-6.620e-01***	-6.606e-01***
Gender	2.316e-02***	2.562e-02***	-	-
# number of children 5 and under (de jure)	3.695e-03***	2.033e-03**	2.733e-03***	3.386e-03***
Age	7.887e-04***	9.462e-04***	8.499e-04***	8.410e-04***
Animal-drawn cart	-9.295e-03.	-1.621e-02**	-1.056e-02*	-9.156e-03.
Bicycle	**2.910e-03**	-4.681e-03*	**1.969e-03**	**1.036e-03**
Motorcycle/scooter	1.340e-02***	9.877e-03***	1.066e-02***	1.221e-02***
Livestock	1.618e-02***	1.429e-02***	1.592e-02***	1.797e-02***
Own land	4.376e-02***	3.960e-02***	4.201e-02***	4.173e-02***
Air conditioner	-4.405e-02***	-4.568e-02***	-4.346e-02***	-4.422e-02***
Electric iron	-5.442e-03.	-8.608e-03**	-5.911e-03.	-6.024e-03*
Fan	-2.866e-02***	-2.944e-02***	-2.950e-02***	-2.950e-02***
Generating set	2.607e-02***	2.707e-02***	2.530e-02***	2.504e-02***
Cable TV	**3.648e-03**	-1.296e-02**	**3.021e-03**	**2.308e-03**
Computer	-3.549e-02***	-3.456e-02***	-3.664e-02***	-3.566e-02***
R^2	0.7845	0.7886	0.7838	0.785
Adjusted R^2	0.7844	0.7885	0.7836	0.7849
F-statistic	^{6431}(19,33566)	^{5217}(24,33561)	^{6759}(18,33568)	^{5329}(23,33563)
p-value	< 2.2e-16	< 2.2e-16	< 2.2e-16	< 2.2e-16

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Source: Author’s calculations derived from the Standard DHS data.

Keeping in mind the aforesaid, Tables 5 and 6 above show the results of the multiple regression analyses for DHS-VI 2013 and DHS-V 2008 for Nigeria. The analysis was carried out with and without the region variable in order to assess its incremental contribution to the model. Additionally, the artificial “region/gender” variable was introduced to showcase the relationship of sex of household, region, and energy deprivation score h_i in Nigeria and will be further used as an experimental treatment for the one-way analysis of variance (ANOVA).

Interpretation of the results seen in Tables 5 and 6, namely average values of about 0.78 and 0.74 of the multiple coefficient of determination (R^2), suggests that the regression line for both datasets fits the data well and thus, 78% and 74%, respectively, of the variance in h_i in Nigeria is explained by the independent variables. In general, the “goodness of fit” is also reconfirmed by almost identical values of the adjusted R^2, as well as by the results of the F tests.

In addition to reconfirming the significance of the R^2, the F test also measures the overall significance of the multiple regression model. Thus, on the basis of the observed F tests and the sufficiently low p value of < 2.2e-16, we may reject the null hypothesis (H_0) under equation (10), i.e. the entire set of independent variables have no effect on the energy deprivation score h_i in Nigeria.

Hence, accepting the alternative hypothesis (H_1) for the models’ overall significance, we turn to verifying the statistical significance of each individual explanatory variable via t test, as specified in equation (9). For this, a 5% value of α was adopted as the minimum significance threshold for the research.

It is important to note that the results of the regression analyses without the region variable and combined “no region/no gender” variable that were tested for their incremental contribution hold up well for both datasets; however, all indicators (e.g. R^2, t test, etc.) suggest keeping those variables in the models. As a result, despite a slight variation in R^2 between the regression models with and without the region variable, as well as with and without the combined “region/gender” variable, the individual significance of the explanatory variables differs considerably. For instance, while the majority of the individual variables lie in the critical region, it is only in the regression model with the region variable for DHS-V 2008 that all individual explanatory variables are considered to be statistically significant. The p value of < 2.2e-16, or the exact probability of committing Type I error, also reconfirms the rejection of the H_0 for each individual regressor for this model.

Nevertheless, while statistically significant, the possession of a bicycle and the variable for the North East region are found to have a weaker effect on energy deprivation in Nigeria as compared to the other independent variables. Such relationships to h_i can be caused by the percentage of missing data in DHS-V 2008; however, what is important is that in the case of the North East region variable, the positive β coefficient observed for both datasets further validates the original MEPI results, and affirms the region as the most energy deprived in the country. In general, an inverse relationship of the β coefficient to the dependent variable indicates a lower degree of energy poverty and vice versa. In fact, the outcomes for the region variable for DHS-VI 2013 and DHS-V 2008 have a similar pattern to the MEPI calculations presented in Appendix E.

The bicycle variable that falls within the mobility category, as specified in Table 4, though statistically significant only in two cases, namely in the regression models with the region variable for DHS-VI 2013 and DHS-V 2008, reveals a positive effect on decreasing energy deprivation. Similarly, the same relationship can be seen for the animal-drawn cart variable. The motorcycle/scooter variable, the final one in the mobility category, has somewhat more controversial results than expected; the β coefficient of the variable has both negative and positive values for the regression models for DHS-VI 2013 and DHS-V 2008, respectively, and in some cases for DHS-VI 2013, has no relationship to or influence on the level of energy deprivation at all and hence, from a statistics view point, supports the truth of the H_0.

Since the negative value of β for the motorcycle/scooter variable is logical and theoretically expected, and the regression models where the variable was considered statistically insignificant are of lesser importance as they were provided only for comparison, we, therefore, try to identify the reasons for the positive β coefficient observed for the 2008 dataset. One potential explanation could be that the price of fuel needed to run the motorcycle/scooter outweighs the benefit of convenient access to the required energy sources and in itself causes inconvenience and energy poverty. In general, whether negative or positive, the β coefficient for the motorcycle/scooter variable indicates a weak influence on h_i; whereas NAs constitute 37% and 48% for DHS-V 2008 and DHS-VI 2013, respectively. Nonetheless, based on this analysis we can refine the conclusion derived in section 2.3.4 and suggest mobility to be further incorporated within the MEPI calculations as, at the minimum, such transport modes as bicycles and animal-drawn carts tend to influence, albeit slightly, the decrease of energy poverty.

The variables consistent with the five dimensions of the MEPI calculation under the entertainment/education appliance ownership and household appliance ownership categories, as well as the earlier investigated variables for wealth and place of residence, which all have a significant effect on h_i, further confirm the MEPI results. As one would expect a priory, energy poverty decreases with an increase in the wealth index, from poorer to richest, and the rural type of residence, or better said the rural population, has a direct relationship with energy deprivation and are those suffering most from energy poverty.

Similarly to the measure of wealth index, the explanatory variables under the entertainment/education appliance ownership and household appliance ownership categories suggest the alleviation of energy poverty. Moreover, these appliances, originally intended to represent the basic energy services required, can be seen as a luxury in a country such as Nigeria and indicate an improved level of living standards. The variable for the possession of a generating set is an exception to the general rule established above, yet intuitively makes sense; the positive value of β could be attributed to the fact that in contrast to the above-mentioned appliances, this variable can be considered as an intermediary resource for securing access to energy. This interpretation implies that the ownership of the generating set in itself is the result of a lack of energy access, unreliable electricity services and constant blackouts (IEA, 2014; EIU, 2015b; web.worldbank.org). Moreover, one should not forget that the generating sets imported and sold in Nigeria are mainly low powered, e.g. 375 kilovolt-ampere (kVA) or 300 kilowatt (kW), able to run no more than a refrigerator in a household that according to our data can comprise of up to more than 30 members (Parkinson, 2011a; Parkinson, 2011b; Nwachukwu, 2011).

Accepting the H_1 individually, the newly tested variables for livestock and land ownership also produce informative results. The explanatory variable for agricultural land ownership does not fully support the previous hypothesis of Mirza/Szirma (2010) that rural landlords are less energy deprived but rather suggests the opposite. On the one hand, this outcome reaffirms that the use of the agricultural crop for cooking is insignificant within the total energy fuel mix as outlined in Figure 7 and Appendix G; on the other hand, one should not forget that this variable does not distinguish between the types of household residence.

Depending on the dataset used, livestock ownership that also includes herds or farm animal ownership has both negative and positive values of β coefficient. For DHS-VI 2013 one can detect an inverse relationship between livestock ownership and energy deprivation, while the opposite is true for DHS-V 2008. We can only assume that the results for the latter are due to a smaller number of responses; however, this can also be attributed to the high level of livestock poverty revealed in the work of Ifelunini et.al. (2013) for Nigeria using national data for 2006. The same applies for land ownership. If this holds true, it could mean that livestock poverty has decreased in the country from 2008 to 2013; whereas land ownership remains consistently weak.

The age of head of household variable, while conditionally grouped within the household composition category, and originally deemed appropriate to be compared with the MEPI calculations, was later dropped due to irrelevant results. The results of the regression analysis imply, however that the older the head of household, the higher the energy deprivation score. While recognizing this as an interesting outcome, it should be considered that the variable is not representative of the entire household's composition.

The variable for the number of household members used only in the multiple regression analysis for DHS-VI 2013, and the number of children 5 and under variable used only for DHS-V 2008, could potentially shed more light on the relationship between household composition and the level of energy deprivation in Nigeria, as well as reconfirm or reject the hypothesis of Pachauri et. al. (2004).

As seen in Table 5, the number of household members variable, while accepting the H_0 and rejecting the H_1, still demonstrates statistically significant results for the regression analysis with the region variable and implies that the greater the number of household members, the lower the energy deprivation in the i^{th} household. To the contrary, we see an increase in energy deprivation in households with a higher number of children 5 and under variable (see Tab. 6). Hence, while the results of the former further verify the assumptions of the scale effect[12] due to household size as reported by Pachauri et. al. (2004), the latter, as previously shown in section 2.3.3, is

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[12] Precisely, on the example of India, Pachauri et. al. (2004) observed the scale effect related to the household size in useful energy consumed for cooking.

unable to prove whether the incremental increase of children will have a less significant influence on energy deprivation than the incremental increase in adults per household, due to the lack of corresponding data. Moreover, while the regression analysis suggests the confirmation of the scale effect of household size, one should not forget that according to Mirza/Szirma (2010) the increase in household size is also associated with some of the inconvenience indicators, such as *"frequency of buying/collecting a source of energy, household member's involvement in energy acquisition and time spent on energy collection per week"* (Mirza/Szirma, 2010, p.12) that normally rise with an increase in household members. Thus, it is also important to consider the quality and level of technical efficiency of appliances available (Pachauri et.al, 2004) and/or uptake cost of a fuel used (Heltberg, 2003), etc. While this concept should be explored further, we consider this beyond the scope of our paper.

The last independent variable under the household composition category is the gender variable that represents the sex of head of household and similar to the age variable, cannot be considered truly representative. Nevertheless, it still provides worthy results; only for DHS-V 2008, does the the variable reject the H_0 and suggest a direct relationship to energy deprivation, meaning that when the number of the female led households increases, the level of energy deprivation goes up. Such an outcome clearly contradicts our findings in section 2.3.3 where according to our previous assessment, households headed by females as compared to male headed ones displayed a minor reduction in the MEPI results for DHS-V 2008; whereas a difference of 18% was observed for DHS-VI 2013.

Before providing any conclusions, it is beneficial to discuss the effect of the combined "region/gender" variable on h_i in Nigeria. As mentioned earlier, this artificially created variable serves simultaneously to showcase the relationship of sex of head of household, region, and energy deprivation score, and as such, would shed more light on gender importance to h_i in different regions of the country.

Before proceeding further and in order to ensure that the nested models are not the same, and the coefficients for both models do not equal 0, we apply the one-way ANOVA. Model 1 or control treatment represents the regression with the region variable; whereas Model 2, experimental treatment, is the regression with the combined "region/gender" variable (see Tables 7 and 8).

Table 7: Two model ANOVA comparison, DHS-VI 2013

Model	Res. Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	37932	873759942				
2	37933	915192505	-1	-41432563	1798.7	<2.2e-16***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: Author's calculations derived from the Standard DHS data.

Table 8: Two model ANOVA comparison, DHS-V 2008

Model	Res. Df	RSS	Df	Sum of Sq	F	Pr(>F)
1	33561	725517049				
2	33562	737833038	-1	-12315988	569.71	<2.2e-16***

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: Author's calculations derived from the Standard DHS data.

As outlined in Tables 7 and 8, the *p* value suggests that we can reject the H_0 and treat the two variables separately in accordance with our models. Thus, being statistically significant except for the "South South region/female" variable for DHS-VI 2013 (see Tables 5 and 6), the "region/gender" variables show, on the whole, similar patterns to the results of the region variables described earlier. However, the results are more pronounced now, implying that with an increase in female led households, energy deprivation, except in the North East region, will, indeed, increase. Alternatively, it can also simply mean that the percentage of female responses as compared to male ones varies significantly across the regions, thus indicating that female led households could have a positive influence on the alleviation of energy poverty.

Coming back to the results of the gender variable in the regression models with the region variable, we can, therefore, assume that the truth of the H_0 for the explanatory variable for the 2013 dataset is explained by the number of responses of the female headed households; whereas the positive coefficient of β for DHS-V 2008 should be taken with caution. Nevertheless, regardless of the results, the influence of gender is notable and affirms the multidimensional aspects of energy poverty.

The full results of the multiple regression analyses for DHS-VI 2013 and DHS-V 2008 for Nigeria are presented in Appendix M.

2.5 Conclusion

By building upon the Multidimensional Energy Poverty Index (MEPI) proposed by Nussbaumer et. al. (2011), we are able to capture the multidimensional aspects of energy poverty and grasp the level of energy deprivation experienced in Nigeria. Thus, we may conclude that while slowly progressing in the right direction, Nigeria in general, continues to suffer from a moderate degree of energy poverty. Delving deeper into this issue in order to accurately capture and assess energy poverty, as well as to avoid a generalization of the results, we observed a significant discrepancy in the level of energy poverty across urban and rural populations, as well as across different states of the country. Meanwhile, while there is a slight improvement in the use of modern fuels in the country, firewood, regardless of the household's place of residence, is still recorded as the preferred source of energy for cooking in Nigeria. Thus, following the work of Karekezi/Majoro (2002), we can acknowledge a high level of energy poor in urban areas of Nigeria that in accordance with Heltberg (2003), are also considered to be more vulnerable to any energy-related price changes than the rural poor. Finally, we also identified a clear correlation between the level of electricity access and the MEPI based on wealth index, while simultaneously recording uneven distribution of energy poverty between the poorest and richest classes in Nigeria. Indirectly embracing the notion of affordability, where the weight of 0.2 or 20% is assigned for the clean cooking dimension, these results additionally showcase the existing dependency between wealth or income distribution and the uptake of clean cooking fuels and hence, on the example of Nigeria, reconfirm a similar conclusion reached by Heltberg (2003).

Recognizing the subjective nature of the MEPI indicators intended to represent the basic energy services required, as referred to in Chapter 1, and to determine the level of energy poverty, we further turned to multiple regression analysis. This analysis has cross-validated the impact of the explanatory variables, chosen based on their availability and consistency with the five dimensions of the original MEPI calculation, on the level of energy deprivation in Nigeria.

As the various dimensions and interactions of indicators of energy poverty are complex, a number of areas, though beyond the scope of this study, deserve further academic research. While our complementary analysis of the influence of household composition on energy poverty brought inconclusive results, it could be of interest to further investigate the overall impact of the number of women with complete primary and/or secondary education on the MEPI results. Similarly, the scale effect of household size in relation to quality and technical efficiency of appliances available (Pachauri et.al. 2004) and/or uptake cost of fuel used (Heltberg, 2003) could shed more light on the level of energy deprivation experienced in Nigerian households. The notion of mobility in the MEPI was only touched upon briefly and a more detailed analysis would still be required. Finally, following the work of Mirza/Szirma (2010), the introduction of two new explanatory variables for the multiple regression analysis, namely livestock and land ownership, though producing informative results, was not able to fully support the hypothesis that rural landlords and households with livestock ownership are less energy deprived. Moreover, if our conclusions are correct, the results have underlined the ongoing land and livestock poverty in Nigeria.

The above-mentioned findings warrant further investigation of causes and potential solutions that will be dealt with in Chapter 3, an analysis of the Nigerian scenario and Chapter 4, implications for potential reform, respectively.

CHAPTER 3. Nigerian Energy Context

Nigeria, with a total population of 183.5 million and real gross domestic product (GDP) growth of 4.3% reported in 2015 and estimated to rise to 6.6% in 2019 (EIU, 2015a), is one of the largest economies in Sub-Saharan Africa (IEA, 2014). The country is rich in natural resources that as announced at the end of 2014, translate into 37.1 billion barrels of total proved oil reserves and 180.1 trillion cubic feet of natural gas. This, in terms of oil and natural gas reserves, places Nigeria as the 2nd and 1st largest in Africa, respectively; with the world's 9th largest natural gas reserves (BP, 2015). Other available natural resources include coal, tar sands, lignite and bitumen. Though mostly untapped, renewable energy, namely hydropower (including small hydropower), solar, wind, biomass, etc. also represent a vast potential in the country (EIU, 2014b; ECN/UNDP, 2012; EREP, 2012; Oyedepo, 2012; Shaaban/Petinrin, 2014)

Notwithstanding the above, the GDP per head was forecasted at US$ 6,017 at purchasing power parity (PPP) for 2015 (EIU, 2015a). Moreover, the HDI identified the country as a low human development one with a 0.504 index score in 2013 (hdr.undp.org). This shows that despite being a fossil fuel rich economy, Nigeria is unable to satisfy its energy demand and in 2012 accounted for approximately 93 million people without electricity access and 115 million relying on traditional biomass to meet their cooking needs (IEA, 2014; EIU, 2015a).

In order to finalize our hypothesis and, in accordance with the empirical results, propose specific recommendations for improved decision-making, the following sections aim to outline the current energy situation in the country and accurately describe the associated national policy frameworks and barriers facing Nigeria.

3.1 Current Energy Scenario

In 2012, Nigeria produced 271.71 million tonnes of oil equivalent (Mtoe) and accounted for 133.74 Mtoe of total primary energy supply (TPES) in the country (OECD/IEA, 2014). According to Economist Intelligence Unit (EIU) estimates, the country produced approximately 2.6 million barrels per day (mb/d) of total liquids, 30,112.1 kilotonnes of oil equivalent (ktoe) of natural gas and 34 ktoe of coal in 2014, indicating a slight increase in energy production, as compared to the previous year.

Overall, the EIU forecasts a steady increase of energy supply leading up to 2020, primarily driven by the growth in natural gas and coal production reaching 38,612.1 ktoe and 230 ktoe, respectively (EIU, 2015a).

However, electricity generation in Nigeria, managed by the Nigerian Electricity Supply Industry (NESI), which in turn is regulated by the Nigerian Electricity Regulatory Commission (NERC), accounts for only 10,396 megawatt (MW) of total installed capacity and 6,056 MW of available capacity, of which 82% originates from thermal units and 18% from hydropower plants (KPMG Advisory Services, 2013). The actual generation capacity is even smaller and was recorded at a historically high level of only 4,517 MW on 23 December 2012 (PFRN, 2013).

Since the successful initiation of the deregulation process in September 2013, the Nigerian power sector now comprises of the government-owned Transmission Company of Nigeria (TCN), with approximately 6,801.49 km and 5,523.8 km of 132 kilovolts (kV) and 330 kV transmission lines, respectively, as well as 6 generation (Gencos) and 11 distribution (Discos) private companies (see Tables 9 and 10) (NIRP, 2014; KPMG Advisory Services, 2013).

Table 9: Generation companies in Nigeria, 2013

#	Generation Company	Plant Type	Capacity (MW)
1	Afam Power Plc	Thermal	987.2
2	Egbin Power Plc	Thermal	1,320
3	Kainji / Jebba Hydro Electric Plc	Hydro	1.330
4	Sapele Power Plc	Thermal	1,020
5	Shiroro Hydro Electric Plc	Hydro	600
6	Ughelli Power Plc	Thermal	942

Source: KPMG Advisory Services, 2013

Table 10: Distribution companies in Nigeria, 2013

#	Distribution Company	Percentage Load Allocation
1	Abuja Distribution Company	11.5%
2	Benin Distribution Company	9%
3	Eko Distribution Company	11%
4	Enugu Distribution Company	9%
5	Ibadan Distribution Company	13%
6	Ikeja Distribution Company	15%
7	Jos Distribution Company	5.5%
8	Kaduna Distribution Company	8%
9	Kano Distribution Company	8%
10	Port Harcourt Distribution Company	6.5%
11	Yola Distribution Company	11.5%

Source: KPMG Advisory Services, 2013

Furthermore, Nigeria can boast around three privately-owned power plants, called Independent Power Projects (IPPs) with combined capacity of 1,374 MW and ten gas-fired power plants under the National Integrated Power Projects (NIPPs) (KPMG Advisory Services, 2013).

Table 11: National Integrated Power Projects (NIPPs) in Nigeria, 2013

#	NIPPS	Capacity (MW)	Expected completion date as at September 2013
1	Alaoji Generation Company Nigeria Limited	1,131	Jun 2014
2	Benin Generation Company Limited	508	Dec 2013
3	Calabar Generation Company Limited	634	Jun 2014
4	Egbema Generation Company Limited	381	Jun 2014
5	Gbarain Generation Company Limited	254	Jun 2014
6	Geregu Generation Company Limited	506	May 2013
7	Ogorode Generation Company Limited	508	All units commissioned
8	Olorunsogo Generation Company Limited	754	All units commissioned
9	Omoko Generation Company Limited	265	Jun 2014
10	Omotosho Generation Company Limited	513	All units commissioned

Source: KPMG Advisory Services, 2013

Yet, as seen in Table 11, the majority of the NIPPs were still under implementation in 2013 and scheduled to be completed and privatized by June 2014 (KPMG Advisory Services, 2013). Unfortunately, due to a lack of information, we cannot confirm whether or not the pending NIPPs were completed and privatized as per the outlined schedules. Nevertheless, it is interesting that with the exception of Geregu Generation Company Limited, which is situated in the North Central geopolitical zone, the other 9 NIPPs are all located in the three least energy deprived zones of the country, namely South West, South South and South East (www.nipptransactions.com).

Moreover, the state government of Lagos, situated in the South West region, has succeeded in commissioning six power projects with total generation capacity of 57.35 MW. All six power projects were developed under the regulation of IPPs and thus, are allowed to establish Public Private Partnerships (PPP). The intention of the state government was to ensure the power supply to public facilities, such as hospitals, universities, etc., to provide additional kilometres of regular street lighting, and to improve the water supply, while simultaneously, as a result of the reduced burden on the underdeveloped national grid, releasing extra watts to households and small businesses (www.lseb.gov.ng). In light of this, it is not surprising that as per our calculations in section 2.3.1, Lagos has the lowest degree of energy poverty in the country, with the MEPI score of only 0.04 and the highest electricity rate, equivalent to 99.48%.

On average, electricity rates in Nigeria remain relatively low with approximately 93 million people, or 55% of the total population reported to live without electricity access in 2012; thus, making the country host to one of the largest populations without electricity (IEA, 2014). The discrepancy between urban and rural areas is also substantial; the World Bank has estimated electricity access of only 34% for rural populations, compared to 84% for urban populations in 2012 (databank.worldbank.org). Moreover, the average monthly electricity bill for a four-person family was recorded as US$ 72.74 and considered unaffordable when compared to the average monthly personal disposable income (EIU, 2015b); while power outages constituted approximately 100 days per year in Nigeria, the African continent as a whole averaged only 56 days per year (IEA, 2014; web.worldbank.org).

Recognizing the poor generation capacity, the Nigerian government has committed to ensure an additional 4,420 MW of generation capacity through both the rehabilitation of existing and construction of new hydroelectric entities by 2020, provided the power sector reform is completed. Furthermore, the thermal-based generation capacity is also envisaged to increase to 20,000 MW by 2020, with a significant contribution coming from the IPPs. An additional 1,000 MW was estimated to potentially originate from coal-fired generation (PFRN, 2013).

It should also be pointed out that the electricity tariff offered in Nigeria is regulated and subsidized; being progressive by nature, the recently amended and established electricity tariff for the period of 2015-2018 amounts to approximately US$ 0.09[13] per kWH for residential customers of the type “R2” (NERC, 2015). Based on metering capacity, residential customers are classified into four categories, with type “R1” representing the most energy deprived consumers, i.e. electricity consumption of less than or equal to 50 kWh; and type “R2” representing those with a monthly consumption of more than 50 kWh over a period of 3 months and using a single and/or 3-phase power supply (NERC, 2012).

Along with electricity prices that in fact are indirectly subsidized via a reduced price for natural gas, the general energy pricing situation in the country is less than ideal. The ongoing attempts by the government to eliminate subsidies and establish the free market price have proved successful only in the case of diesel; whereas the subsidies for oil products (e.g. gasoline, kerosene) and natural gas were only slightly reduced. In September 2014, according to the IEA (2014), the Nigerian government approved US$1.3 billion for a bailout package for electricity entities with the purpose of filling the gap between the subsidized and real prices of electricity; while in 2013, a total amount of US$6.5 billion was estimated to have been spent on fossil-fuel subsidies. Exacerbating the situation, the low price for products, such as gasoline and kerosene, also encourages smuggling to neighboring countries. In Nigeria itself these products can be purchased at the officially set price from only a few retailers in large cities, while the price for most consumers is much higher due to the transaction costs of multiple retailers (IEA, 2014). Though the price for other oil products, for instance LPG, is considered to be market driven, it is clear that these significant subsidies represent a huge burden for the country’s economy and in reality do not benefit those who require them the most (IEA, 2014; AfDB, 2013).

Other hindrances experienced by Nigerian energy customers, both industrial and households, include the poor state of the country’s four refineries, and the transmission and distribution losses coupled with inadequate infrastructure, among others.

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[13] Exchange rate of the local currency (Nigerian Naira) per US Dollar (27.08.2015): 198.95 NGN/US$

The refineries were reported to operate at an average of 22% of full capacity in 2013 and only 4.1% in September 2014, while losses amounted to roughly 8 terawatt-hours (TWh) with an estimated 25% loss rate in 2012. In other words, an average of 8 TWh of electricity that could potentially be consumed by end users was lost; and the significant below-capacity operation of the refineries translates into approximately 80% of refined fuels being imported to Nigeria, thus having a substantial impact on the country's economic development (IEA, 2014; EIU, 2015b).

Additionally, verifying the MEPI results at the regional level, it is noteworthy that depsite the fact that refineries are operating below original capacity and produce only premium motor spirit, automotive gas oil and household kerosene, in 2014 the majority of these products were distributed to the South West region. The North East region, the most energy deprived according to our calculations, placed second from last, regaining its position with the smallest slice of petroleum products distributed to the region in April 2015 (NNPC 2014; NNPC 2015).

The continued lack of access to electricity in Nigeria indicates that the current installed generation capacity and distribution networks are not sufficient to meet the country's growing demand, leading to a strong reliance on expensive and polluting stand-alone diesel or gasoline generators and excessive use of biomass. The IEA (2014) has estimated around 12 TWh of electricity demand in Nigeria is met by these generators, with households accounting for roughly 2 TWh of this in 2012; while 115 million people or 68% of the total population used biomass for cooking. For comparison purposes, only 40 million people were reported to use biomass for cooking in urban areas (IEA, 2014).

In general, regardless of the household's place of residence, fuelwood, kerosene and charcoal were recorded as the preferred sources of energy for cooking in Nigeria; whereas other fuels such as electricity, LPG, natural gas, coal and lignite, though insignificant within the total energy fuel mix, prevailed in urban areas, which is in line with the data obtained from DHS (see Fig.7 and App. G) (IEA, 2014; EIU, 2015b). The limited use of natural gas is also not surprising and can be considered as the nation's missed opportunity; such factors as limited infrastructure and under-pricing explain high export sales, whilst only 9% of Nigeria's growing demand is satisfied by natural gas (IEA, 2014; EIU, 2015b). Flaring is also an issue, with 48.37 billion standard cubic feet (BSCF) flared in April 2015 alone (NNPC, 2015).

In light of the abovementioned issues, it is evident that Nigeria is not coping with increasing energy demand that is projected to reach 251 Mtoe by 2040 according to the New Policy Scenario conducted by the IEA (2014); with forecasted electricity demand of 291 TWh (IEA, 2014). This section has clearly highlighted the need for drastic change, where collective efforts, strong government support, and coherent, as well as feasible policies and energy reforms can make a difference. Thus, the following section aims to review the existing and planned energy related policies to further grasp the causal sequence of the prevailing energy situation in Nigeria.

3.2 Energy Policy and Institutional Framework

The objective of this section is to explore and accurately evaluate the key strategy documents and policy frameworks specifically devoted to the energy sector of Nigeria. While the oil and gas sector is a significant part of the overall energy sector and of high importance to Nigeria, it is not a priority focus of this paper and exceeds its scope. Thus, the author will primarily concentrate on power sector initiatives to provide the context in which the aforementioned operate and only briefly outline the current legislation in the oil and gas sector, as well as the renewable energy sector.

The Global Energy Architecture Performance Index Report 2015 identifies efficient energy reform as that *“reaching beyond immediate imperatives to build capacity for future resilience”* (WEF, 2014a, p. 5). In other words, such reform should be able to guarantee an affordable, sustainable and secure energy system, hence contributing to the competitiveness and economic growth of a country. Effective governance structures, public and private sector engagement, and smooth implementation are thus, the key elements of a successful energy policy (WEF, 2014a; Shaad/Wilson, 2009; Osabuohien et.al, 2012; Oyedepo, 2012).

Shortly after Nigeria’s declaration of independence in 1960, a number of short-, medium- and long-term plans were developed, all oriented around key macroeconomic objectives, such as infrastructural and socio-economic development, industrialization and economic growth. However, only after adopting a new constitution on 5 May 1999, did the country embark on a democratic path with the core national policy frameworks, strategies, laws and regulations developed and enacted to recognize the need for energy infrastructure development (Olaseni/Alade, 2012; Osabuohien et.al, 2012; Ohunakin et.al, 2011). Following international trends, the use and contribution of the country's renewable energy resources were also reflected in those frameworks and strategies (Ohunakin et.al, 2011; Akinyemi et.al, 2014).

The National Economic Empowerment and Development Strategy (NEEDS), accompanied by the State Economic Empowerment and Development Strategies (SEEDS) and the Local Economic Empowerment and Development Strategies (LEEDS), was the first example of a national long-term strategy. Formulated in 2004, the strategy aims at supporting small and medium-sized enterprises, reforming the financial sector and reducing poverty among others. As a means for achieving these goals, the power sector, especially electricity, was highlighted as a top priority (Osabuohien et.al, 2012; NIRP, 2014; NNPC, 2004). Therefore, generation capacity of 10,000 MW, transmission capacity of 9,340 Megavolt ampere (MVA), distribution capacity of 15,165 MVA and 15% of transmission and distribution losses were targeted to be achieved by 2007. Moreover, the use of grid and off-grid systems to increase access to electricity in rural areas, use of alternative energy sources, such as coal, solar, wind and hydropower, engagement of the private sector, and privatization and liberalization of the electricity industry were proposed (NNPC, 2004).

NEEDS, as well as the National Electric Power Policy of 2001, gave an impetus for the approval of the Electric Power Sector Reform Act (EPSRA 2005) in 2005. The most relevant aspect of this law was the exemption of a license requirement for off-grid electricity generators not exceeding a total of 1 MW at one site (NNPC, 2004; EPSRA 2005; Ohunakin et.al, 2011). In addition, through EPSRA 2005, NERC, Power Holding Company of Nigeria (PHCN), Rural Electrification Agency (REA) and the Rural Electrification Fund (REF) were established. While the purpose of NERC is to regulate the entire electricity sector, PHCN, the successor of the former National Electric Power Authority, is an attempt of the Government to deregulate it (EPSRA 2005; Ohunakin et.al, 2011; Olaseni/Alade, 2012). Originally, created only for 18 months, the PHCN was successfully unbundled only in September 2013, and the TCN, 6 Gencos and 11 Discos were formed (Olaseni/Alade, 2012; NIRP, 2014; KPMG Advisory Services, 2013).

Vision 20:2020 is another example of the country's long-term strategies. The blueprint, based on research of the American Investment Bank, 7-Point Agenda and the successor of NEEDS, was first introduced in 2006 and endorsed in 2010, with the purpose of placing Nigeria among the 20 largest economies in the world and anticipating a grid generation capacity of 35,000 MW by 2020 (Osabuohien et. al, 2012; Olaseni/Alade, 2012; Cervigni et. al, 2013, 17; AfDB 2013; Vision 20:2020, 2009). Originally divided into three medium-term national implementation plans to begin in 2009, the strategy envisages a shift from an agriculture and crude-oil driven economy to a manufacturing and service oriented one, while considering improvement in institutional, social and environmental aspects (Vision 20:2020, 2009; AfDB, 2013; Cervigni et.al, 2013, 18).

In the context of energy access and energy security, Vision 20:2020 encourages a diverse mix of energy sources to support on- and off-grid electrification; namely, resumption of the electric power sector privatization process along with the provision of a legal and regulatory background, and strengthening of the State Governments' roles to attract private investment and establish PPPs; development of the oil and gas sector in the hope of stimulating refinery capacity and meeting the domestic demand for gas; and the introduction of demand-side energy management, etc. In addition, the strategy considers energy, in particular renewable energy, as a potential means of job creation and poverty reduction (Vision 20:2020, 2009).

In a similar vein, the newly approved Nigeria Industrial Revolution Plan (NIRP), as well as the Transformation Agenda, to run from 2011 until 2015, confirm the commitment of the Nigerian Government to further strengthen and stimulate the power, and oil and gas sectors of the country (NIRP, 2014; NPC, n.d.).

The Plan and Agenda both refer to the Power Sector Reform Roadmap launched by the Nigerian president in 2010 and revised to indicate attained results and major barriers in 2013. Apart from building on the legacy of EPSRA 2005 and Vision 20:2020 and incorporating the larger part of the earlier mentioned objectives, the Roadmap prioritizes hydro (including small hydro), coal and natural gas for power generation as the least capital intensive and time-consuming in their development. Nuclear power was also included in the total energy mix in the long term perspective (NIRP, 2014; NPC, n.d.; PFRN, 2010; PFRN, 2013).

The IPPs, initially legalized in 2000 to allow decentralized construction of power plants in partnership with the private sector, and the NIPPs, conceived in 2004 and specifically designed for gas-fired power plants, were also resumed through the

Power Sector Reform Roadmap, with the main goal of adding additional megawatts for generating capacity (Shaad/Wilson, 2009; PFRN, 2010; PFRN, 2013). Furthermore, the rehabilitation of all existing power plants in the short term, an increase in transmission capacity with an associated construction of an Ultra High Voltage (UHV) network and the introduction of an adequate price/tariff regime, etc. were envisaged (Cervigni et.al, 2013, p.77-111; NPC, n.d.; PFRN, 2010; PFRN, 2013).

In this regard, the government succeeded in establishing a Bulk Purchaser, namely the Nigeria Bulk Electricity Trading Plc (NBET) and introducing the Multi-Year Tariff Order (MYTO). Specifically, NBET is designed to stimulate private sector investment through the execution of Power Purchase Agreements (PPAs) with existing and emerging IPPs, and guide the transitional stage of the electricity market via purchasing and reselling electric power from generating to distributing companies, respectively. Being entirely owned by the government, the NBET will ultimately be terminated once the newly established distribution companies are considered commercially viable enough to secure electric power privately (PFRN, 2010; PFRN, 2013; NIRP, 2014; KPMG Advisory Services, 2013). Moreover, in order to make PPAs bankable and creditworthy, the government agreed to provide credit enhancement to NBET (PFRN, 2010; PFRN, 2013).

MYTO, in turn, determines an objective and cost-reflecting electricity pricing regime for the Nigerian Electricity Supply Industry, and is regulated by NERC in line with EPSRA 2005. Introduced in 2008 for a 15-year period, the tariff order has undergone several major reviews, resulting in the release of the amended MYTO for the period from 1 April 2015 to December 2018 (NERC, 2012; NERC, 2015; KPMG Advisory Services, 2013; PFRN, 2013; NIRP, 2014). Amending past omissions, the new order includes Feed-in Tariffs for renewable energy, as well as developing tariffs for coal-fired generators (NERC, 2012). Although focusing on revenue improvements, the tariff order has not removed subsidies or increased tariffs to ultimately protect consumers, but has instead focused on progress in the metering system and elimination of technical, commercial and collection losses (NERC, 2012).

Specifically on the subject of renewable energy, which is included and addressed in all of the above-mentioned strategies and frameworks, as well as the National Energy Policy 2003, Renewable Energy Master Plan 2005, Renewable Electricity

Policy Guidelines 2006, Nigerian Bio-fuel Policy and Incentives 2007, and the recently introduced Feed-in Tariff, Nigeria can boast the improved and updated version of the Renewable Energy Master Plan (REMP) (ECN/UNDP, 2012; FRN, 2007; FMPS, 2006; PECN, 2003).

The revised and concise REMP of 2012, prepared with the financial support of the United Nations Development Programme, identifies the precise activities, responsible parties, proposed sources of funding and implementation timeline needed to accelerate a low carbon economy in the country, where renewable energy should constitute approximately 20% of the total energy mix by 2030. For this, three growth scenarios for electricity, heat and fuel supply, based on an annual GDP growth of 7%, 10% and 13% were considered. While recognizing the overall role of renewable energy and the strong link between energy access and socio-economic development, the Master Plan also seeks to address the mitigation and adaptation challenges of climate change, and promote research and development, as well as public awareness of the topic. In addition, economic and fiscal incentives (e.g. tax holiday, investment grants, etc.), potential risks, standards and codes were specified and highlighted in the master plan (ECN/UNDP, 2012).

On the regional level, Nigeria, being a part of the Economic Community of West African States (ECOWAS),[14] has adopted in 2013 the ECOWAS Renewable Energy Policy (EREP) and the ECOWAS Energy Efficiency Policy (EEEP), and is now in the process of finalizing the complementary National Renewable and Energy Efficiency Action Plans as a part of SE4All (ECOWAS, 2014). Nigeria's 2nd National Communication to the United Nations Framework Convention on Climate Change 2014 also highlights the importance of the energy sector as the main emitter of greenhouse gases (GHGs), as well as enhancing renewable energy and energy efficiency for the mitigation strategies of the Nigerian government (FME, 2014).

Although the oil and gas sector is not a priority focus of this paper, to acknowledge its importance in the country it is worth mentioning that a draft Petroleum Industry Bill (PIB), an ambitious attempt of the government to liberalize the sector by ensuring transparency, establishing comprehensive legislation and penalties for gas flaring,

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[14] The Economic Community of West Africa States (ECOWAS), established in 1975 in Lagos, Nigeria, comprises of 15 sovereign states, namely: Benin, Burkina Faso, Cabo Verde, Cote d'Ivoire, the Gambia, Ghana, Guinea, Guinea Bissau, Liberia, Mali, Niger, Nigeria, Senegal, Sierra Leone and Togo.

etc., is still awaited to be enacted by the government (NAFR, 2012; AfDB, 2013; Schiere, 2012; EIU, 2014; EIU, 2015b).

3.3 Conclusion

Having reviewed the key policies and strategies of the Nigerian energy sector, and considering the issues highlighted in section 3.1 of this paper, we can conclude that despite the tremendous amount of policy initiatives, none can claim to be effective in their implementation. A similar conclusion was reached by Osabuohien et. al. (2012) while comparing the national economic planning of Nigeria, Botswana and South Korea from 1962 to 2011; the authors argued that a lack of proper planning, government commitment and close consultations with the various actors hindered the achievement of the set goals (Osabuohien et.al, 2012).

Overall, factors such as corruption, a “new government new policy” approach, weak implementation, overlap of the responsibilities between key players, vandalism and oil thefts, poor status of national infrastructure, as well as refineries etc., are hindering Nigeria to unleash its vast energy potential and stimulate socio-economic development (Osabuohien et.al, 2012; Schiere, 2012; AfDB, 2013; Olaseni/Alade, 2012; Akinyemi et. al, 2014; Agba, 2011; GNESD, 2004; IEA, 2014; Onyeji et.al, 2012). While numerous additional hindering factors could be highlighted, it is clear that lack of natural or human resources are not the main cause of the poor status of the energy sector in Nigeria; and recognizing this, energy governance should be seen as a separate topic of research when discussing the economic and social development of Nigeria.

CHAPTER 4. Implications for Reform

Chapter 2 has shown the value of the MEPI as it, based on the proposed set of basic energy needs, determines the level and intensity of energy poverty in a country, as well as the headcount ratio of energy poor. The subset analysis conducted, in turn, allowed us to thoroughly demonstrate the impact of and relationship between the selected individual indicators (Nussbaumer et.al, 2011; Nussbaumer et.al, 2013). Some of those additional indicators appear to be promising determinants of energy poverty, while others are simply helpful in investigating the existing discrepancy in a country. Additionally, the former once again prove the complexity and multidimensional nature of energy poverty, while the latter help to avoid a generalization of the results that are often rendered invisible in official statistics (Heltberg, 2003). Thus, these findings form a solid foundation for effective and targeted planning of poverty inclusive policies that is currently lacking in Nigeria.

Underlining the various applications of the MEPI to Nigeria by other scholars as highlighted in Chapter 1, we can observe a similar overall pattern to our analysis; yet the MEPI results vary quite significantly. Apart from using a different data source, and applying a different weighting system and cut-off, this difference can be attributed to the set of indicators chosen to determine energy deprivation in Nigeria; from five dimensions proposed by Nussbaumer et. al. (2011), only two of them, namely cooking (including indoor pollution indicator) and lighting dimensions were utilized (Edoumiekumo et.al, 2013; Edoumiekumo/Karimo, 2014; Apere/Karimo, 2014; Sher et.al, 2014).

Therefore, while reconfirming a lack of consensus on the basic energy needs (Practical Action, 2010; Pachauri, 2011; Nussbaumer et.al, 2011), the above-mentioned comparison of analyses shows the substantial impact of the selected variables on the energy deprivation score on the example of Nigeria. It is hard to say which of the suggested approaches to the MEPI calculation could be considered ideal, but it is clear that this variance in energy deprivation scores points to the value of using the MEPI as an analysis tool; allowing researches to tailor the proposed methodology to the specific needs of their research, while also better reflecting the larger energy poverty scenario in their selected country of analysis (Nussbaumer et.al, 2011; Nussbaumer et.al, 2013).

In conclusion, the approach taken in Chapter 2 suggests to further consider mobility as one of the potential dimensions for the MEPI calculations, especially in light of the projected growth of car ownership in the country by 2040 (IEA, 2014). Moreover, based on the controversial results obtained from the multiple regression analysis, it could also be deemed appropriate to distinguish between fuel- and human/animal-powered transport modes. Assuming our conclusion is correct and the ownership of a fuel-powered transport mode exceeds the benefits of convenient access to the required energy sources, we would stress the need to promote renewable energy in the form of biofuels that can be locally produced and is already supported by available legislation and national strategy plans (EREP, 2012; ECN/UNDP, 2012; FRN, 2007).

On the whole, the advantages of renewable energy have been discussed at length by various authors (EREP, 2012; ECN/UNDP, 2012; GNESD, 2004; Shaaban/Petinrin, 2014; Oyedepo, 2012; Bhide/Monroy, 2011; Cervigni et.al, 2013; Ohunakin et.al, 2011; Onyeji et.al, 2012). Taking into account the empirical evidence of urban and rural discrepancy observed among different geopolitical zones and states of Nigeria, it, therefore, also proves beneficial to look into renewable energy off-grid solutions as a suitable remedy for addressing the challenges of energy poverty, particularly in remote rural areas. Solar electrification in South Africa, biomass initiatives in Brazil, and the promotion of small-hydro power, PV systems and wind generators in Peru and China, are just some examples of successful rural energy access projects, supported by national policies. Moreover, off-grid electrification powered by renewable energy has the advantage of replacing the costly diesel and gasoline needed to run stand-alone generating sets that according to our findings have a direct relationship with the level of energy deprivation in the country (GNESD, 2004).

By large, close consultations with and involvement of the various actors, “ring-fencing” of the existing Rural Electrification Fund (REA), proper capacity building and possible reduction of the upfront costs for electricity connection, etc. are other complementary actions and initiatives that ideally should be considered during the formulation of the national policies and strategy plans; providing that local conditions and cultural preferences are taken into account (GNESD, 2004; Onyeji et.al, 2012; Osabuohien et.al, 2012).

As seen from section 3.2, Nigeria can boast a number of the required regulatory measures for successful combating energy poverty; i.e. established governmental bodies to monitor the implementation of reforms in the power sector, resumed legislation for IPPs and NIPPs, license exemptions for off-grid electricity generators of less or equal to 1 MW, and generic targets for quality improvement and extension of the national grid, etc. (EPSRA 2005; PRFN, 2010; PRFN, 2013). However, while it is still early to judge the effectiveness of the newly established monitoring bodies – the Presidential Action Committee on Power (PACP) and the Presidential Task Force on Power (PTFP), other initiatives and targets are barely working and in most cases can even have a negative impact on the energy poor population (Onyeji et.al, 2012; GNESD, 2004; PRFN, 2010; PRFN, 2013).

The reason for this is that the national policies normally concentrate only on the technical aspects, such as improvement of the electricity supply quality for those who already have access to it, and overlook the needs of rural and income poor dwellers (Onyeji et.al, 2012; Sambo, 2009). The results obtained in Chapter 2, as well as the insights of the current energy scenario provided in section 3.1, clearly confirm this. Nigerian rural communities are those suffering the highest levels of energy deprivation; with electricity rates ranging from 0.39% in rural parts of Yobe state to 94.17% in Ekiti state (see App. F). Findings also indicate that while the MEPI results for the rural population improved slightly from 2013 as compared to 2008, the results for the urban population stayed almost unchanged (see App. D). Clearly, neither the rapid population growth nor the needs of the urban poor are taken into consideration in the country’s existing policy framework. Moreover, even the existing NIPPs, as well as the distribution of refined products, omits the most energy deprived regions. Following the recommendations of the Global Network on Energy for Sustainable Development (GNESD) (2004), we would thus recommend to explicitly state and advocate quantative energy access targets for both urban and rural poor, if comprehensive changes are to be achieved.

Acknowledging that the proper uptake of modern energy fuels is considered only after the electricity connection is in place (Heltberg, 2003; Pereira et.al, 2010), we would, nonetheless, also emphasize the need for specific quantitative targets devoted especially to the promotion of modern energy fuels. The results of our analysis support this suggestion and are quite straightforward – modern energy fuels, having the highest representation among the six MEPI indicators, are those influencing the MEPI score the most. The average MEPI score of 0.57 indicates that the uptake of modern energy fuels is far from ideal in Nigeria and has not changed much between 2003 and 2013, not to mention the associated indoor pollution.

While additionally touching upon the issue of affordability, these findings have increased our understanding of the energy profile for cooking in Nigerian households. A carefully targeted subsidy campaign, with subsidized modern fuels being available to those who require them the most, as well as an overall focus on easy access to a variety of modern fuels available on the market, could be a solution to the current situation. As per our findings, for instance, improved access to subsidized kerosene is deemed to be more beneficial in the rural parts of the country, provided that it is not only used for fuel-powered transport modes; whereas subsidies for LPG, natural gas and biogas, as well as the overall dissemination of modern energy fuels, should be considered for urban Nigeria. Alternatively, a single time subsidy could also be provided for the uptake of particular modern energy fuels and/or electricity connenction, especially in light of the ongoing attempts of the Nigerian government to reduce the burden of subsidies on the economy. A focus on efficient and low-cost technologies and appliances for both urban and rural poor, as well as increased ownership of livestock and land, particularly in rural areas, could also offer a suitable remedy to energy poverty alleviation, especially when the community is not yet ready to adopt modern energy fuels (Heltberg, 2003; GNESD, 2004; Karekezi/Majoro, 2002; Mirza/Szirma, 2010; Ifelunini et.al, 2013). Moreover, it should be pointed out that land ownership and land reform, in particular, have proven to reduce income inequality, as well as stimulate economic growth and stability in a country. Here, the case of South Korea could serve as a relevant example for Nigeria, where land reform is considered as a part of a broader rural development strategy (Putzel, 2000; Deininger, 2001; Bezemer/Headey, 2008; Ifelunini et.al, 2013).

Though the results of the influence of household composition on energy deprivation were not quite pertinent, it is still obvious that such factors as household size, gender and age, etc. should be taken into account in the policy formulation process (Anyanwu, 2010; Pachauri et.al, 2004; Mirza/Szirma, 2010). Women empowerment to combat energy poverty, though exceeding the scope of this study, is another interesting topic for investigation in Nigeria. The MEPI results, as well as those of the multiple regression analyses, indicated that the role of gender should be treated with caution, implying that energy poverty, as well as poverty in general, are not gender-neutral (Anyanwu, 2010; UNIDO/UN Women, 2013; UNIDO, 2014). The use of the artificial “region/gender” variables in the multiple regression analyses also suggests the presence of a relationship between sex of household, region, and the energy deprivation score in Nigeria, which in turn, is in line with the work of Anyanwu (2010). For instance, one can observe a drop in energy deprivation with an increase in the number of female-headed households in the South-West region; whereas the opposite has been revealed for other regions.

Thus, keeping in mind the obtained gender related results that seem logical when considering the overall regional energy deprivation scores and religious divisions in the country, we would suggest to further focus not only on promotion of gender equality, stipulated by the National Gender Policy of 2007, but specifically on a reduction of the regional gender inequality (e.g. regional educational programmes, etc.), stimulation of entrepreneurial activities and increase in land ownership by women in the country (OECD, 2010; JICA, 2011; British Counsil Nigeria, 2012; AfDB, 2013; WEF, 2014b; Anyanwu, 2010). The Gender in Nigeria Report 2012 supports our suggestion. Women were reported to constitute approximately 49% of the entire population, or 80 million people in 2011, with the majory living in rural areas; whereas only 20% of women were involved in the formal sector and in 2006 only 7.2% owned land. Unsurprisingly, the southern parts of Nigeria were those accounting for a higher percentage of both female entrepreneurship and land ownership compared to the northern parts (British Council Nigeria, 2012). Moreover, apart from the apparent advantages of these initiatives, such as increase in family well-being and poverty alleviation, etc., it would also be beneficial to expand women empowerment by including them in all processes related to electrification, as well as awareness raising and capacity-building campaigns on the topic, as suggested by GNESD (2004) and noted in section 2.3.3 of this study (GNESD, 2004; British Council Nigeria, 2012; Anyanwu, 2010).

Lastly, throughout our research, our ability to properly utilize national statistical data was limited as it was either outdated or partially unavailable. Following the recommendations of numerous scholars, where the availability of local data and information is outlined as one of the success factors in the formulation of effective reforms and as pointed out by Bambawale et. al. 2011, should ideally be provided before the start of any substantial energy related initiave (Heltberg, 2003; Bambawale et.al, 2011; Bazilian et.al, 2011; Nussbaumer et.al, 2013), we would stress the need of the obvious – systematic collection of standardized national data.

Based on the empirical results, this chapter highlighted the omissions of and possible alternatives to current policy reforms with the aim to improve energy access in Nigeria. In general, policy frameworks, as well as all domestic reforms, are developed to ensure the achievement of a country's targets and to boost sustainable economic growth, while improving the well-being of its citizens (Shaad/Wilson, 2009; COM (2013) 92 final). Nigeria, for all of its resource potential and numerous energy policy initiatives, is still unable to satisfy the growing energy demand or in general, guarantee stable access to energy. To do so, the Nigerian government must concentrate their efforts on a select number of statistically proven interventions, be it subsidy approach or alternative cooking fuels, etc., rather than a "Jack of all trades, master of none" approach. This will require a roll out strategy that starts from one village and effectively spreads throughout the whole country[15].

While the above-mentioned suggestions do not ensure success, will not be easy to implement, and should be considered only as complementary suggestions, they clearly highlight the need for the government to achieve the effective and complete implementation of realistic goals based on empirical evidence of the nature of energy deprivation in Nigeria.

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[15] The roll out concept was discussed and suggested by Mr. Paul Harris, International consultant, UNIDO, who has worked in the energy sector for 30 years, starting in the power sector on a 3,000 MW coal power station, before focusing on the end usage of electricity and fuels by consumers (23.10.2015, Kampala, Uganda).

CONCLUSION

The current energy situation in Nigeria and the overall importance of energy access call for a clearer understanding of the complexity of multidimensional energy poverty experienced in the country, as well as an investigation of the causes and potential solutions. Utilizing the newly proposed Multidimensional Energy Poverty Index (MEPI) and further conducting a set of multiple regression analyses, this study has classified Nigeria as one with a moderate degree of multidimensional energy poverty. In reconfirming the majority of known assumptions and relationships purported in the energy poverty literature and shedding some light on the current energy poverty distribution in Nigeria, we briefly touched upon the notion of household composition and mobility in the MEPI, as well as assessed the impact of additional explanatory variables, such as livestock and land ownership, etc. on energy deprivation in the country.

Overall, this study, while providing academic proof of the value and flexibility of using the MEPI as an appropriate analysis tool to better reflect the larger energy poverty scenario in a selected country of analysis, also highlights the real world applications in the form of suggestions to ensure improved implementation of existing and planned national policies and strategies based on appropriate empirical data. This can only be achieved, however, when the real energy needs of a single household, regional specifications and gender discrepancy, to name only a few factors and relationships that influence the level of energy deprivation, are fully investigated and understood.

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ABSTRACT (ENGLISH)

Nigeria, despite being one of the largest economies in Sub-Saharan Africa and possessing vast resources of both renewable and non-renewable energy, is host to one of the largest populations without electricity access. Building upon the Multidimensional Energy Poverty Index (MEPI) and further conducting a set of multiple regression analyses, this paper aims to capture and assess the complex nature of energy poverty and the level of energy deprivation experienced in Nigerian households based on the data of the Demographic and Health Surveys (DHS) for 2003, 2008 and 2013. While observing a slight improvement in the country's efforts in expanding energy access to mitigate energy poverty, and investigating causes and potential solutions based on the empirical results, we conclude that despite the large amount of policy initiatives, none can claim to be effective in their implementation and sufficient in the face of rapid population growth and increasing energy demand. Thus, we stress the need for the national government to pursue the consistent and effective implementation of existing and planned national policies and strategies aimed at ensuring reliable, efficient and universal energy access. Finally, acknowledging that the MEPI is a relatively new approach, we purport the value of using the MEPI as an appropriate analysis tool; allowing researchers to tailor the proposed methodology to the specific needs of the research, while also better reflecting the larger energy poverty scenario in their selected country of analysis.

ABSTRACT (GERMAN)

Nigeria ist eine der größten und bedeutsamsten Volkswirtschaften der afrikanischen Sub-Saharazone und verfügt über reichhaltige erneuerbare sowie nicht erneuerbare Energieressourcen. Dennoch ist der Energiezugang – in all seinen Ausprägungen – für den Großteil der Landesbevölkerung stark eingeschränkt und im Verhältnis zur wirtschaftlichen Stellung des Landes in seinem geographischen und ökonomischen Umfeld wenig entwickelt. Die gegenständliche Arbeit untersucht anhand des Multidimensional Energy Poverty Index (MEPI) und der Methodik multipler Regressionsanalyse die Komplexität dieses eingeschränkten Energiezugangs samt dem jeweiligen Grad der Einschränkung am Beispiel nigerianischer Einfamilien-Haushalte. Als Grundlage der Untersuchung dienen die Daten des Demographic and Health Surveys (DHS) der Jahre 2003, 2008 und 2013, wodurch ein zeitlicher Vergleich darstellbar ist. Durch die Untersuchung wird ersichtlich, dass trotz einer signifikanten Steigerung der Lösungsbemühungen und politischen Initiativen, keiner der bisherigen Schritte geeignet war, dem durch das rapide Bevölkerungswachstum bedingten, wachsenden Energiehunger in adäquater Weise zu begegnen. Es ist daher die unabdingbare Notwendigkeit hervorzuheben, bereits existierende nationale Programme zu forcieren und neue Strategien zur Verwirklichung eines verlässlichen, effizienten und universellen Energiezugangs für die gesamte Bevölkerung zu schaffen. MEPI kann hierbei als wertvolles Analyse-Instrument dienen, weil eine maßgeschneiderte Anpassung der zur Anwendung gelangendem Methodik ermöglicht wird, die eine detaillierte und aussagekräftige Darstellung von Energiearmutsszenarien in den untersuchten Länder zulässt.

Appendix A: Routine: ALL INDICATORS

```
##################
RStudio, Version 0.98.501
Author: Olga Gordiievska
Creation Date: 21.03.2015
##################

library(foreign)
data <- read.spss("~/../Desktop/MEPI/Nigeria V, 2008/NGHR52FL_small1.SAV",
use.value.labels = TRUE, to.data.frame=TRUE)

#calculate indicators (missing data = mean value)
##################

#cooking fuel
g_type_cooking_fuel <- ifelse(data$HV226 != "Electricity" & data$HV226 != "LPG" & data$H
V226 !="Natural gas" & data$HV226 !="Biogas" & data$HV226 !="Kerosene", 0.2, 0)
tot=length(g_type_cooking_fuel)
na=sum(is.na(g_type_cooking_fuel))
cat("NA-Cooking:",na,"/",tot,"(",na*100/tot,"percent)\n")
#stove
g_open_stove <- ifelse(g_type_cooking_fuel != 0 & data$HV239 != "Closed stove with chimn
ey" & data$HV240 == "Neither chimney or hood" & data$HV241!= "Outdoors", 0.2, 0)
g_type_cooking_fuel[is.na(g_type_cooking_fuel)] <- mean(g_type_cooking_fuel, na.rm=TRU
E)
na=sum(is.na(g_open_stove))
cat("NA-Stove:",na,"/",tot,"(",na*100/tot,"percent)\n")
g_open_stove [is.na(g_open_stove)] <-mean(g_open_stove, na.rm=TRUE)
#electricity
g_electricity <-ifelse(data$HV206 != "Yes", 0.2, 0)
na=sum(is.na(g_electricity))
cat("NA-Electricity:",na,"/",tot,"(",na*100/tot,"percent)\n")
g_electricity[is.na(g_electricity)] <-mean(g_electricity, na.rm=TRUE)
#fridge
g_fridge <- ifelse(data$HV209 != "Yes", 0.1333, 0)
na=sum(is.na(g_fridge))
cat("NA-Fridge:",na,"/",tot,"(",na*100/tot,"percent)\n")
g_fridge[is.na(g_fridge)] <-mean(g_fridge, na.rm=TRUE)
#radio or tv
g_radio_tv <- ifelse(data$HV207 != "Yes" & data$HV208 != "Yes", 0.1333, 0)
na=sum(is.na(g_radio_tv))
cat("NA-RadioTv:",na,"/",tot,"(",na*100/tot,"percent)\n")
g_radio_tv[is.na(g_radio_tv)] <-mean(g_radio_tv, na.rm=TRUE)
#phone or mobile
g_phone <- ifelse (data$HV221 != "Yes" & data$HV243A != "Yes", 0.1333, 0)
cat("NA-Phone:",na,"/",tot,"(",na*100/tot,"percent)\n")
g_phone[is.na(g_phone)] <-mean(g_phone, na.rm=TRUE)

#deprivation
##################

#deprivation vector
c <- (g_type_cooking_fuel + g_open_stove + g_electricity + g_fridge + g_radio_tv + g_phone)
#censored deprevation vector (cut-off)
```

```
c_k <- ifelse(c > 0.3,c, 0)

#headcount
##################

#headcount vector
headcount_weighted <- data$HV005 * data$HV009
#total headcount
tot_hc <- sum(headcount_weighted)
#headcount vector poor (cut-off)
headcount_weighted_poor <- ifelse (c_k,headcount_weighted,0)
headcount_weighted_poor[is.na(headcount_weighted_poor)] <-0
#total headcount poor
tot_hc_poor <- sum(headcount_weighted_poor)

#headcount ratio
H <- (tot_hc_poor/tot_hc)

#intensity
##################

#weighted censored deprevation vector
c_k_weighted <- (c_k*headcount_weighted)
c_k_weighted[is.na(c_k_weighted)] <-0
#"total poverty"
tot_c_k_weighted <- sum(c_k_weighted)

#poverty intensity
A <- (tot_c_k_weighted/tot_hc_poor)

#MEPI
##################
MEPI <- (H*A)

##################
cat("HV226 (FuelType):",attr(data,"variable.labels")["HV226"],"\n")
cat("HV239 (Stove):",attr(data,"variable.labels")["HV239"],"\n")
cat("HV240 (Chimney):",attr(data,"variable.labels")["HV240"],"\n")
cat("HV241 (Outdoors):",attr(data,"variable.labels")["HV241"],"\n")
cat("HV206 (Electricity):",attr(data,"variable.labels")["HV206"],"\n")
cat("HV209 (Fridge):",attr(data,"variable.labels")["HV209"],"\n")
cat("HV207 (Radio):",attr(data,"variable.labels")["HV207"],"\n")
cat("HV208 (TV):",attr(data,"variable.labels")["HV208"],"\n")
cat("HV221 (Phone):",attr(data,"variable.labels")["HV221"],"\n")
cat("HV243A (Mobile):",attr(data,"variable.labels")["HV243A"],"\n")
cat("HV005 (weight):",attr(data,"variable.labels")["HV005"],"\n")
cat("HV009 (householdSize):",attr(data,"variable.labels")["HV009"],"\n")


# electricity calculation
##################

#convert data from yes no to 1,0
elec = ifelse(data$HV206 == "Yes",1,0)
#inflate data (times householdsize and weight)
elec_rate = elec*data$HV005*data$HV009
```

```
#calculate how much data is NA
exclude_count = sum(is.na(elec_rate))
#output NA data sum
cat("Data NA: ",exclude_count,"\n")
#exclude NA data
elec_rate[is.na(elec_rate)] <- 0
#calculate sum
cat("no. of ppl with electricity:",sum(elec_rate),"\n")
#calculate total headcount
total_hc=data$HV005*data$HV009
#exclude NA data
total_hc[is.na(elec_rate)] <- 0
#calculate sum
cat("total no. of ppl (NA excluded):",sum(total_hc),"\n")
#calculate percentage
cat("percentage:",sum(elec_rate)*100/sum(total_hc),"%\n")
```

Appendix B: MEPI for selected countries of the Sub-Saharan region

#	Dataset/Year	Country	Total			Urban			Rural		
			H	A	MEPI	H	A	MEPI	H	A	MEPI
1	VI / 2011-12	Benin	0.95	0.73	0.70	0.89	0.64	0.57	1	0.79	0.79
2	VI / 2010	Burkino Faso	0.97	0.80	0.78	0.87	0.67	0.59	1	0.83	0.83
3	VI / 2010	Burundi	1	0.88	0.88	0.99	0.66	0.65	1	0.90	0.90
4	VI / 2011	Cameroon*	0.81	0.68	0.56	0.63	0.53	0.33	0.98	0.77	0.76
5	VI / 2012	Comoros	0.82	0.65	0.54	0.55	0.59	0.33	0.95	0.67	0.64
6	VI / 2011-12	Congo (Brazzaville)	0.79	0.71	0.56	0.69	0.63	0.44	0.97	0.82	0.79
7	VI / 2013-14	Congo DR	0.98	0.84	0.83	0.94	0.70	0.66	1	0.92	0.92
8	VI / 2011-12	Cote d'Ivoire*	0.82	0.60	0.49	0.64	0.48	0.30	0.97	0.66	0.65
9	VI / 2011	Ethiopia	0.98	0.87	0.86	0.88	0.63	0.55	1	0.92	0.92
10	VI / 2012	Gabon	0.19	0.67	0.13	0.1	0.57	0.56	0.69	0.73	0.51
11	V / 2008	Ghana**	0.83	0.65	0.54	0.54	0.67	0.36	0.96	0.71	0.69
12	VI / 2012	Guinea	1	0.75	0.75	1	0.56	0.56	1	0.84	0.84
13	VI / 2008-09	Kenya	0.92	0.79	0.73	0.62	0.65	0.41	0.99	0.81	0.81
14	VI / 2009	Lesotho*	0.84	0.64	0.53	0.50	0.44	0.22	0.94	0.67	0.63
15	VI / 2013	Liberia	1	0.80	0.80	1	0.75	0.75	1	0.86	0.86
16	V / 2008-09	Madagascar*	0.98	0.81	0.80	0.92	0.57	0.52	0.99	0.85	0.85
17	VI / 2010	Malawi*	0.97	0.79	0.77	0.86	0.64	0.55	1	0.82	0.82
18	VI / 2012-13	Mali	1	0.73	0.73	0.99	0.56	0.55	1	0.78	0.78
19	VI / 2011	Mozambique	0.97	0.82	0.79	0.91	0.66	0.60	1	0.89	0.88
20	VI / 2013	Namibia	0.66	0.71	0.47	0.35	0.59	0.20	0.94	0.75	0.71
21	VI / 2012	Niger	1	0.82	0.81	0.96	0.63	0.61	1	0.85	0.85
22	VI / 2013	Nigeria	0.80	0.70	0.56	0.58	0.59	0.34	0.95	0.75	0.71
23	VI / 2010	Rwanda	1	0.83	0.83	1	0.68	0.68	1	0.85	0.85
24	V / 2008-09	Sao Tome & Principe**	0.76	0.69	0.52	0.63	0.66	0.42	0.90	0.71	0.64

#	Dataset/Year	Country	Total			Urban			Rural		
			H	A	MEPI	H	A	MEPI	H	A	MEPI
25	VI / 2010-11	Senegal	0.72	0.67	0.49	0.44	0.55	0.25	0.95	0.72	0.68
26	VI / 2013	Sierra Leone*	0.94	0.64	0.6	0.82	0.54	0.44	1	0.67	0.67
27	V / 2006-07	Swaziland**	0.72	0.63	0.45	0.37	0.60	0.22	0.82	0.62	0.51
28	VI / 2010	Tanzania	0.98	0.82	0.8	0.93	0.66	0.62	1	0.86	0.86
29	VI / 2011	Uganda	1	0.8	0.79	0.97	0.64	0.62	1	0.82	0.82
30	V / 2007	Zambia*	0.83	0.79	0.66	0.57	0.69	0.39	0.98	0.82	0.80
31	VI / 2010-11	Zimbabwe	0.74	0.85	0.63	0.25	0.67	0.16	0.96	0.87	0.83

* Only countries with the complete set of data. For other countries, the data for at least two variables under the “indoor pollution” indicator was missing. Since the “indoor pollution” indicator is one of the elements under the cooking dimension, we have, in accordance with the work of Nussbaumer et.al. (2013), removed the indicator, while reassigning the weight of 0.2 to the “modern cooking fuel” indicator.

** In this case, the data for only one variable, namely “*Household have a chimney, hood or neither*” under the “indoor pollution” indicator was missing. Hence, the variable was removed without further deleting the entire “indoor pollution” indicator.

Source: Author’s calculations derived from the Standard DHS data.

Appendix C: Data availability for selected countries of the Sub-Saharan region

#	Dataset/Year	Country	HV206[16]	HV207	HV208	HV209	HV221	HV226	HV239	HV240	HV241	HV243A
			Electricity	**Radio**	**TV**	**Fridge**	**Phone (land-line)**	**Cooking fuel**	**Food cooked on a stove or open fire**	**Chimney, hood or neither**	**Food cooked in the house/separate build-ing/outdoors**	**Mobile phone**
1	VI / 2011-12	Benin	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
2	VI / 2010	Burkino Faso	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
3	VI / 2010	Burundi	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
4	VI / 2011	Cameroon	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	VI / 2012	Comoros	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
6	VI / 2011-12	Congo (Brazzaville)	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
7	VI / 2013-14	Congo DR	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
8	VI / 2011-12	Cote d'Ivoire	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
9	VI / 2011	Ethiopia	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
10	VI / 2012	Gabon	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
11	V / 2008	Ghana	✓	✓	✓	✓	✓	✓		**NA**	✓	✓
12	VI / 2012	Guinea	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
13	VI / 2008-09	Kenya	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
14	VI / 2009	Lesotho	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
15	VI / 2013	Liberia	✓	✓	✓	✓	**NA**	✓	**NA**	**NA**	✓	✓
16	V / 2008-09	Madagascar	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
17	VI / 2010	Malawi	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓

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[16] HV206 – HV243A refer to the codes of the variables used in the DHS.

#	Dataset/Year	Country	HV206[16]	HV207	HV208	HV209	HV221	HV226	HV239	HV240	HV241	HV243A
			Electricity	**Radio**	**TV**	**Fridge**	**Phone (land-line)**	**Cooking fuel**	**Food cooked on a stove or open fire**	**Chimney, hood or neither**	**Food cooked in the house/separate building/outdoors**	**Mobile phone**
18	VI / 2012-13	Mali	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
19	VI / 2011	Mozambique	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
20	VI / 2013	Namibia	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
21	VI / 2012	Niger	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
22a	VI / 2013	Nigeria	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
22b	V / 2008	Nigeria	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
22c	IV / 2003	Nigeria	✓	✓	✓	✓	✓	✓	**NA**	**NA**	**NA**	**NA**
23	VI / 2010	Rwanda	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
24	V / 2008-09	Sao Tome & Principe	✓	✓	✓	✓	✓	✓	✓	**NA**	✓	✓
25	VI / 2010-11	Senegal	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
26	VI / 2013	Sierra Leone	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
27	V / 2006-07	Swaziland	✓	✓	✓	✓	✓	✓	✓	**NA**	✓	✓
28	VI / 2010	Tanzania	✓	✓	✓	✓	✓	✓	**NA**	**NA**	**NA**	✓
29	VI / 2011	Uganda	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓
30	V / 2007	Zambia	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
31	VI / 2010-11	Zimbabwe	✓	✓	✓	✓	✓	✓	**NA**	**NA**	✓	✓

Source: Standard DHS Surveys data

Appendix D: MEPI and corresponding electricity rates for various Standard DHS for Nigeria

Dataset/Year	Total				Urban				Rural			
	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate
VI / 2013	0.78	0.66	0.51	52.78%	0.55	0.53	0.29	83.01%	0.94	0.70	0.66	32.76%
V / 2008	0.79	0.71	0.56	47.93%	0.52	0.57	0.29	84.24%	0.93	0.75	0.70	29.81%
IV / 2003	0.79	0.80	0.64	51.23%	0.55	0.70	0.39	83.94%	0.92	0.84	0.77	34.60%

Source: Author’s calculations derived from the Standard DHS data.

Appendix E: MEPI for geopolitical zones and corresponding electricity rates for various Standard DHS for Nigeria

Geopolitical zones	VI / 2013				V / 2008				IV / 2003			
	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate
North Central	0.86	0.66	0.56	45.41%	0.88	0.72	0.63	32.51%	0.89	0.80	0.71	47.10%
North East	0.98	0.73	0.71	30.86%	0.98	0.77	0.76	25.11%	0.97	0.83	0.81	34.75%
North West	0.93	0.69	0.65	43.51%	0.94	0.76	0.72	38.57%	0.92	0.81	0.74	44.85%
South East	0.71	0.56	0.40	64.55%	0.75	0.62	0.47	64.59%	0.53	0.76	0.41	67.38%
South South	0.61	0.58	0.35	68.56%	0.71	0.65	0.46	56.73%	0.73	0.79	0.57	55.76%
South West	0.40	0.51	0.21	80.81%	0.49	0.62	0.31	70.70%	0.38	0.77	0.29	80.41%

Note: The 6 geopolitical zones of Nigeria include the following states:

- North West: Kebbi, Sokoto, Zamfara, Katsina, Kano, Jigawa, Kaduna
- North Central: Niger, Kwara, FCT – Abuja, Kogi, Nasarawa, Plateau, Benue
- North East: Bauchi, Yobe, Borno, Gombe, Adamawa, Taraba
- South West: Oyo, Ogun, Osun, Ondo, Ekiti, Lagos
- South South: Edo, Delta, Bayelsa, Rivers, AkwaIbom, Cross River
- South East: Enugu, Imo, Anambra, Ebonyi, Abia

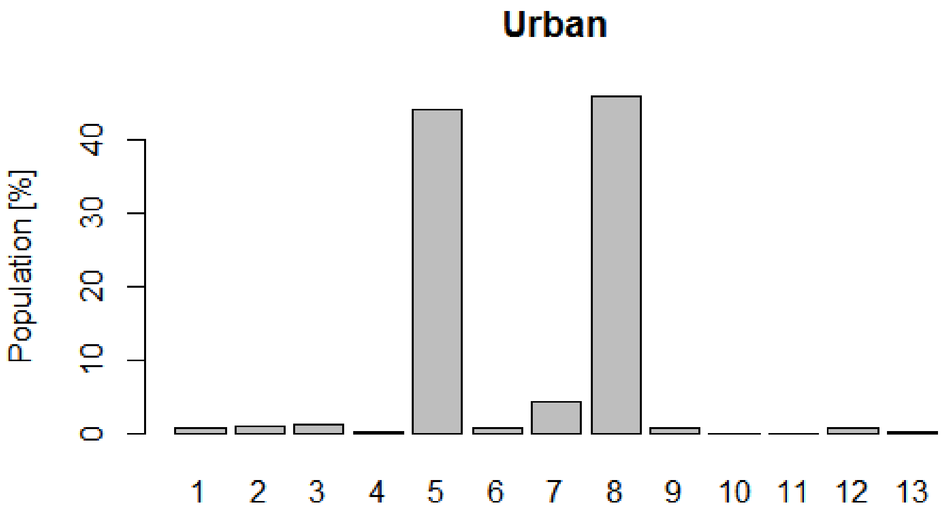
Source: Author’s calculations derived from the Standard DHS data.

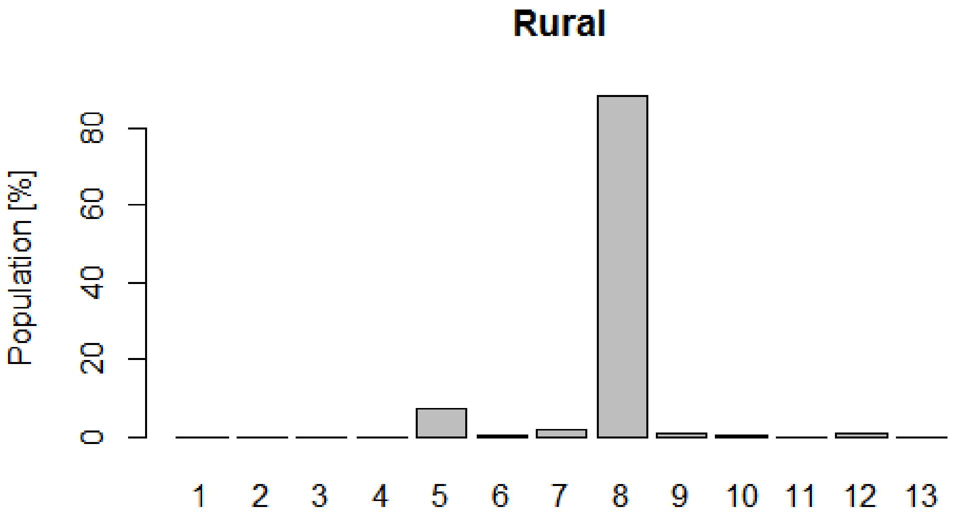
Appendix F: MEPI at state levels for DHS-VI 2013 for Nigeria

States	Urban				Rural			
	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate
Sokoto	0.94	0.54	0.51	82.56%	1	0.73	0.73	29.39%
Zamfara	0.96	0.55	0.53	89.37%	1	0.76	0.76	20.01%
Katsina	0.96	0.54	0.52	93.25%	1	0.76	0.76	20.31%
Jigawa	0.91	0.53	0.48	88.17%	1	0.76	0.76	24.29%
Yobe	0.95	0.52	0.50	85.23%	1	0.74	0.74	0.39%
Borno	0.93	0.61	0.57	71.94%	1	0.87	0.87	8.00%
Adamawa	0.83	0.55	0.46	76.31%	1	0.74	0.74	26.62%
Gombe	0.95	0.60	0.57	77.15%	1	0.76	0.75	36.44%
Bauchi	0.97	0.54	0.53	83.87%	1	0.77	0.77	23.31%
Kano	0.78	0.57	0.45	79.45%	1	0.74	0.73	35.92%
Kaduna	0.55	0.50	0.28	89.72%	0.99	0.67	0.67	17.60%
Kebbi	0.91	0.56	0.51	84.61%	0.99	0.73	0.72	37.29%
Niger	0.72	0.45	0.32	99.91%	0.98	0.66	0.65	42.02%
Abuja	0.15	0.42	0.06	93.20%	0.82	0.58	0.47	41.28%
Nasarawa	0.70	0.50	0.35	84.55%	0.95	0.70	0.67	13.93%
Plateau	0.49	0.52	0.25	88.44%	0.99	0.80	0.79	11.72%
Taraba	0.72	0.63	0.45	48.33%	1	0.78	0.78	2.24%
Benue	0.75	0.51	0.38	85.88%	0.98	0.76	0.75	14.41%
Kogi	0.57	0.47	0.26	90.64%	0.86	0.56	0.48	45.62%
Kwara	0.62	0.47	0.29	88.00%	0.70	0.44	0.31	93.50%
Oyo	0.43	0.43	0.18	78.41%	0.97	0.58	0.56	34.27%
Osun	0.42	0.46	0.19	93.67%	0.79	0.50	0.39	74.23%
Ekiti	0.48	0.47	0.23	92.80%	0.72	0.46	0.33	94.17%
Ondo	0.33	0.46	0.15	94.22%	0.85	0.62	0.53	33.50%
Edo	0.38	0.48	0.18	98.47%	0.70	0.57	0.40	60.93%
Anambra	0.35	0.51	0.18	89.30%	0.79	0.54	0.43	73.54%
Enugu	0.77	0.59	0.46	49.64%	0.94	0.54	0.51	64.05%
Ebonyi	0.92	0.58	0.54	34.65%	0.69	0.58	0.40	61.20%
Cross River	0.38	0.44	0.17	97.61%	0.89	0.59	0.53	49.03%
Akwa Ibom	0.27	0.48	0.13	97.33%	0.70	0.61	0.42	63.82%
Abia	0.22	0.48	0.11	97.55%	0.90	0.58	0.52	76.96%
Imo	0.72	0.56	0.40	66.78%	0.70	0.56	0.39	73.36%
Rivers	0.18	0.42	0.07	90.27%	0.89	0.62	0.55	46.31%
Bayelsa	0.38	0.56	0.21	77.11%	0.65	0.58	0.38	38.88%
Delta	0.40	0.53	0.21	90.45%	0.71	0.59	0.42	67.12%
Lagos	0.08	0.44	0.04	99.48%	-	-	-	-
Ogun	0.19	0.46	0.09	92.15%	0.66	0.58	0.38	55.96%

Source: Author’s calculations derived from the Standard DHS data.

Appendix G: Use of cooking fuels in Nigeria, 2008





Note: [1] electricity; [2] LPG; [3] natural gas; [4] biogas; [5] kerosene; [6] coal, lignite; [7] charcoal; [8] wood; [9] straw/shrubs/grass; [10] agricultural crop; [11] animal dung; [12] no food cooked in household; [13] other.

Source: Author's calculations derived from the Standard DHS data.

Appendix H: MEPI based on wealth index and corresponding electricity rates for various Standard DHS for Nigeria

Wealth index	VI / 2013				V / 2008				IV / 2003			
	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate	H	A	MEPI	Electricity rate
Poorest	1	0.81	0.81	7.34%	1	0.88	0.88	1.57%	1	0.94	0.94	1.26%
Poorer	1	0.73	0.73	22.70%	1	0.80	0.80	14.16%	1	0.89	0.89	11.74%
Middle	0.99	0.61	0.60	50.31%	0.99	0.68	0.67	43.04%	1	0.77	0.77	50.88%
Richer	0.75	0.48	0.36	86.03%	0.78	0.50	0.39	84.65%	0.82	0.63	0.51	92.28%
Richest	0.19	0.43	0.08	96.97%	0.18	0.42	0.08	95.80%	0.15	0.52	0.08	99.49%

Source: Authors calculations derived from the Standard DHS data.

Appendix I: Stepwise Backward Regressions for DHS-VI 2013 and DHS-V 2008 for Nigeria

###################
RStudio, Version 0.98.501
Author: Olga Gordiievska
Creation Date: 18.07.2015
###################

a) DHS-VI 2013

```
Start:  AIC=381010.5
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions +
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle
+ dummies.motorcycle_scooter + dummies.car_truck +
dummies.animal_drawn_cart + dummies.boat + dummies.cable_tv +
dummies.generating_set + dummies.air_c + dummies.computer + dummies.e_iron
+ dummies.fan + no.na.data[["data.HV220"]] + no.na.data[["data.HV014"]] +
no.na.data[["data.HV009"]]
```

```
                             Df Sum of Sq        RSS    AIC
- no.na.data[["data.HV014"]]  1        14  872920787 381008
- dummies.car_truck           1     25445  872946218 381010
- dummies.boat                1     27115  872947887 381010
<none>                                     872920773 381010
- no.na.data[["data.HV009"]]  1    141563  873062335 381015
- dummies.bicycle             1    195872  873116644 381017
- dummies.motorcycle_scooter  1    325901  873246674 381023
- dummies.livestock           1    498293  873419066 381030
- dummies.computer            1    549041  873469814 381032
- dummies.animal_drawn_cart   1    844291  873765063 381045
- dummies.e_iron              1    900724  873821497 381048
- dummies.gender              1    997848  873918621 381052
- dummies.air_c               1   1978693  874899466 381094
- dummies.cable_tv            1   2783728  875704500 381129
- dummies.own_land            1   3364063  876284835 381154
- dummies.generating_set      1   5630943  878551715 381252
- dummies.residence           1   6498929  879419702 381290
- no.na.data[["data.HV220"]]  1   7009733  879930505 381312
- dummies.fan                 1   9047241  881968014 381400
- dummies.regions             5  54451353  927372125 383296
- dummies.wealth              4 230352405 1103273178 389885
```

```
Step:  AIC=381008.5
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions +
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle
+ dummies.motorcycle_scooter + dummies.car_truck +
dummies.animal_drawn_cart + dummies.boat + dummies.cable_tv +
dummies.generating_set + dummies.air_c + dummies.computer + dummies.e_iron
+ dummies.fan + no.na.data[["data.HV220"]] + no.na.data[["data.HV009"]]
```

```
                             Df Sum of Sq        RSS    AIC
- dummies.car_truck           1     25454  872946241 381008
- dummies.boat                1     27117  872947904 381008
<none>                                     872920787 381008
- dummies.bicycle             1    195959  873116746 381015
- no.na.data[["data.HV009"]]  1    262481  873183268 381018
- dummies.motorcycle_scooter  1    325976  873246763 381021
- dummies.livestock           1    498552  873419339 381028
- dummies.computer            1    549312  873470099 381030
- dummies.animal_drawn_cart   1    844377  873765163 381043
- dummies.e_iron              1    900777  873821564 381046
- dummies.gender              1    997991  873918777 381050
- dummies.air_c               1   1978788  874899575 381092
- dummies.cable_tv            1   2783716  875704503 381127
- dummies.own_land            1   3364137  876284924 381152
```

```
- dummies.generating_set      1   5631418  878552205 381250
- dummies.residence           1   6499249  879420036 381288
- no.na.data[["data.HV220"]]  1   7996208  880916995 381352
- dummies.fan                 1   9047696  881968482 381398
- dummies.regions             5  54498284  927419071 383295
- dummies.wealth              4 230996785 1103917572 389905

Step:  AIC=381007.6
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions +
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle
+ dummies.motorcycle_scooter + dummies.animal_drawn_cart + dummies.boat +
dummies.cable_tv + dummies.generating_set + dummies.air_c +
dummies.computer + dummies.e_iron + dummies.fan +
no.na.data[["data.HV220"]] + no.na.data[["data.HV009"]]

                             Df Sum of Sq        RSS    AIC
- dummies.boat                1     27129  872973370 381007
<none>                                     872946241 381008
- dummies.bicycle             1    194787  873141028 381014
- no.na.data[["data.HV009"]]  1    251459  873197700 381017
- dummies.motorcycle_scooter  1    332666  873278906 381020
- dummies.livestock           1    492899  873439140 381027
- dummies.computer            1    527412  873473653 381028
- dummies.animal_drawn_cart   1    840088  873786328 381042
- dummies.e_iron              1    896625  873842865 381045
- dummies.gender              1    986917  873933158 381048
- dummies.air_c               1   1953349  874899590 381090
- dummies.cable_tv            1   2758999  875705240 381125
- dummies.own_land            1   3385120  876331360 381152
- dummies.generating_set      1   5726567  878672808 381254
- dummies.residence           1   6514379  879460620 381288
- no.na.data[["data.HV220"]]  1   8065089  881011330 381354
- dummies.fan                 1   9057445  882003686 381397
- dummies.regions             5  54619941  927566182 383300
- dummies.wealth              4 233503942 1106450183 389990

Step:  AIC=381006.8
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions +
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle
+ dummies.motorcycle_scooter + dummies.animal_drawn_cart + dummies.cable_tv
+ dummies.generating_set + dummies.air_c + dummies.computer +
dummies.e_iron + dummies.fan + no.na.data[["data.HV220"]] +
no.na.data[["data.HV009"]]

                             Df Sum of Sq        RSS    AIC
<none>                                     872973370 381007
- dummies.bicycle             1    194400  873167770 381013
- no.na.data[["data.HV009"]]  1    248787  873222157 381016
- dummies.motorcycle_scooter  1    333556  873306926 381019
- dummies.livestock           1    490283  873463653 381026
- dummies.computer            1    528535  873501906 381028
- dummies.animal_drawn_cart   1    840263  873813633 381041
- dummies.e_iron              1    898840  873872210 381044
- dummies.gender              1    983321  873956691 381047
- dummies.air_c               1   1950347  874923717 381089
- dummies.cable_tv            1   2762754  875736124 381125
- dummies.own_land            1   3377967  876351337 381151
- dummies.generating_set      1   5745351  878718721 381254
- dummies.residence           1   6526262  879499632 381287
- no.na.data[["data.HV220"]]  1   8064261  881037631 381354
- dummies.fan                 1   9033229  882006599 381395
- dummies.regions             5  54637737  927611107 383299
- dummies.wealth              4 233598639 1106572009 389992

Call:
lm(formula = no.na.data[["c"]] ~ dummies.wealth + dummies.gender +
dummies.regions + dummies.residence + dummies.livestock + dummies.own_land
+ dummies.bicycle + dummies.motorcycle_scooter + dummies.animal_drawn_cart
+ dummies.cable_tv + dummies.generating_set + dummies.air_c +
dummies.computer + dummies.e_iron + dummies.fan +
no.na.data[["data.HV220"]] + no.na.data[["data.HV009"]], weights =
```

```
no.na.data[["data.HV005"]], na.action = na.exclude)

Coefficients:
(Intercept)                          dummies.wealth(Intercept)
0.7334907                                                 NA
dummies.wealth.fPoorer               dummies.wealth.fMiddle
-0.0612819                                        -0.1680909
dummies.wealth.fRicher               dummies.wealth.fRichest
-0.3318891                                        -0.5296007
dummies.gender(Intercept)            dummies.gender.fFemale
NA                                          0.0142610
dummies.regions(Intercept)              dummies.regions.fNorth East
NA                                          0.0435108
dummies.regions.fNorth West             dummies.regions.fSouth East
-0.0050067                                 -0.0511557
dummies.regions.fSouth South            dummies.regions.fSouth West
-0.0652996                                 -0.0990661
dummies.residence(Intercept)            dummies.residence.fRural
NA                                          0.0362192
dummies.livestock(Intercept)            dummies.livestock.fYes
NA                                         -0.0093926
dummies.own_land(Intercept)             dummies.own_land.fYes
NA                                          0.0256940
dummies.bicycle(Intercept)              dummies.bicycle.fYes
NA                                         -0.0062024
dummies.motorcycle_scooter(Intercept)   dummies.motorcycle_scooter.fYes
NA                                         -0.0070506
dummies.animal_drawn_cart(Intercept)    dummies.animal_drawn_cart.fYes
NA                                         -0.0263011
dummies.cable_tv(Intercept)             dummies.cable_tv.fYes
NA                                         -0.0354705
dummies.generating_set(Intercept)       dummies.generating_set.fYes
NA                                          0.0358085
dummies.air_c(Intercept)                dummies.air_cair_c.fYes
NA                                         -0.0508879
dummies.computer(Intercept)             dummies.computer.fYes
NA                                         -0.0205963
dummies.e_iron(Intercept)               dummies.e_iron.fYes
NA                                         -0.0169887
dummies.fan(Intercept)                  dummies.fan.fYes
NA                                         -0.0573988
no.na.data[["data.HV220"]]              no.na.data[["data.HV009"]]
0.0009667                                         -0.0009210
```

b) DHS-V 2008

```
Start:  AIC=335022.3
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions + 
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle 
+ dummies.motorcycle_scooter + dummies.car_truck + 
dummies.animal_drawn_cart + dummies.boat + dummies.cable_tv + 
dummies.generating_set + dummies.air_c + dummies.computer + dummies.e_iron 
+ dummies.fan + no.na.data[["data.HV220"]] + no.na.data[["data.HV014"]] + 
no.na.data[["data.HV009"]]
```

```
                             Df Sum of Sq        RSS    AIC
- dummies.car_truck           1      1587  725189225 335020
- no.na.data[["data.HV009"]]  1      8421  725196058 335021
- dummies.boat                1     22934  725210572 335021
<none>                                     725187638 335022
- no.na.data[["data.HV014"]]  1     51254  725238891 335023
- dummies.bicycle             1    116948  725304585 335026
- dummies.e_iron              1    176075  725363713 335028
- dummies.cable_tv            1    192082  725379720 335029
- dummies.animal_drawn_cart   1    212581  725400218 335030
- dummies.motorcycle_scooter  1    494024  725681661 335043
- dummies.computer            1    832045  726019682 335059
- dummies.livestock           1   1059670  726247307 335069
- dummies.air_c               1   1077169  726264807 335070
- dummies.fan                 1   1634959  726822596 335096
- dummies.generating_set      1   2270117  727457754 335125
- dummies.gender              1   3026098  728213735 335160
- dummies.residence           1   5395069  730582707 335269
- no.na.data[["data.HV220"]]  1   5957623  731145261 335295
- dummies.own_land            1   7241021  732428659 335354
- dummies.regions             5  13999086  739186724 335654
- dummies.wealth              4 288346775 1013534413 346249
```

```
Step:  AIC=335020.4
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions + 
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle 
+ dummies.motorcycle_scooter + dummies.animal_drawn_cart + dummies.boat + 
dummies.cable_tv + dummies.generating_set + dummies.air_c + 
dummies.computer + dummies.e_iron + dummies.fan + no.na.data[["data.HV220"]
] + no.na.data[["data.HV014"]] + no.na.data[["data.HV009"]]
```

```
                             Df Sum of Sq        RSS    AIC
- no.na.data[["data.HV009"]]  1      8803  725198028 335019
- dummies.boat                1     22847  725212072 335019
<none>                                     725189225 335020
- no.na.data[["data.HV014"]]  1     51152  725240377 335021
- dummies.bicycle             1    116828  725306053 335024
- dummies.e_iron              1    175846  725365071 335027
- dummies.cable_tv            1    190551  725379776 335027
- dummies.animal_drawn_cart   1    212412  725401637 335028
- dummies.motorcycle_scooter  1    492657  725681882 335041
- dummies.computer            1    833071  726022296 335057
- dummies.livestock           1   1062225  726251450 335068
- dummies.air_c               1   1089542  726278767 335069
- dummies.fan                 1   1637228  726826453 335094
- dummies.generating_set      1   2315217  727504442 335125
- dummies.gender              1   3024528  728213753 335158
- dummies.residence           1   5398486  730587711 335267
- no.na.data[["data.HV220"]]  1   5980753  731169978 335294
- dummies.own_land            1   7256406  732445631 335353
- dummies.regions             5  14007790  739197015 335652
- dummies.wealth              4 293357592 1018546817 346413
```

```
Step:  AIC=335018.8
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions + 
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle 
+ dummies.motorcycle_scooter + dummies.animal_drawn_cart + dummies.boat + 
dummies.cable_tv + dummies.generating_set + dummies.air_c + 
```

```
dummies.computer+ dummies.e_iron + dummies.fan + no.na.data[["data.HV220"]]
 + no.na.data[["data.HV014"]]

                             Df Sum of Sq        RSS    AIC
- dummies.boat                1     23638  725221666 335018
<none>                                     725198028 335019
- dummies.bicycle             1    112312  725310341 335022
- no.na.data[["data.HV014"]]  1    152580  725350608 335024
- dummies.e_iron              1    173106  725371134 335025
- dummies.cable_tv            1    189345  725387373 335026
- dummies.animal_drawn_cart   1    209982  725408010 335027
- dummies.motorcycle_scooter  1    505735  725703764 335040
- dummies.computer            1    830370  726028398 335055
- dummies.air_c               1   1089311  726287340 335067
- dummies.livestock           1   1101641  726299669 335068
- dummies.fan                 1   1635284  726833313 335092
- dummies.generating_set      1   2325418  727523446 335124
- dummies.gender              1   3028601  728226629 335157
- dummies.residence           1   5391498  730589526 335265
- no.na.data[["data.HV220"]]  1   7166954  732364982 335347
- dummies.own_land            1   7272355  732470383 335352
- dummies.regions             5  14195819  739393847 335659
- dummies.wealth              4 293452228 1018650257 346414

Step:  AIC=335017.9
no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.regions + 
dummies.residence + dummies.livestock + dummies.own_land + dummies.bicycle 
+ dummies.motorcycle_scooter + dummies.animal_drawn_cart + dummies.cable_tv 
+ dummies.generating_set + dummies.air_c + dummies.computer + 
dummies.e_iron + dummies.fan + no.na.data[["data.HV220"]] + 
no.na.data[["data.HV014"]]

                             Df Sum of Sq        RSS    AIC
<none>                                     725221666 335018
- dummies.bicycle             1    113128  725334794 335021
- no.na.data[["data.HV014"]]  1    152771  725374437 335023
- dummies.e_iron              1    173732  725395398 335024
- dummies.cable_tv            1    188171  725409837 335025
- dummies.animal_drawn_cart   1    207692  725429358 335026
- dummies.motorcycle_scooter  1    504687  725726353 335039
- dummies.computer            1    832383  726054049 335054
- dummies.air_c               1   1087253  726308919 335066
- dummies.livestock           1   1102489  726324155 335067
- dummies.fan                 1   1629305  726850971 335091
- dummies.generating_set      1   2344081  727565747 335124
- dummies.gender              1   3022443  728244109 335155
- dummies.residence           1   5402858  730624524 335265
- no.na.data[["data.HV220"]]  1   7169332  732390998 335346
- dummies.own_land            1   7262584  732484250 335350
- dummies.regions             5  14186607  739408273 335658
- dummies.wealth              4 293535319 1018756985 346416

Call:
lm(formula = no.na.data[["c"]] ~ dummies.wealth + dummies.gender + dummies.
regions + dummies.residence + dummies.livestock + dummies.own_land + dummie
s.bicycle + dummies.motorcycle_scooter + dummies.animal_drawn_cart + dummie
s.cable_tv + dummies.generating_set + dummies.air_c + dummies.computer + du
mmies.e_iron + dummies.fan + no.na.data[["data.HV220"]] + no.na.data[["data
.HV014"]], weights = no.na.data[["data.HV005"]], na.action = na.exclude)

Coefficients:
(Intercept)                             dummies.wealth(Intercept)  
0.7496689                                      NA  
dummies.wealth.fPoorer                  dummies.wealth.fMiddle  
-0.0654401                                 -0.1763172  
dummies.wealth.fRicher                  dummies.wealth.fRichest  
-0.4003349                                 -0.6320825  
dummies.gender(Intercept)               dummies.gender.fFemale  
NA                                          0.0255853  
dummies.regions(Intercept)              dummies.regions.fNorth East  
NA                                          0.0057018  
```

```
dummies.regions.fNorth West             dummies.regions.fSouth East
0.0107838                                  -0.0149626
dummies.regions.fSouth South            dummies.regions.fSouth West
-0.0151819                                 -0.0549830
dummies.residence(Intercept)            dummies.residence.fRural
NA                                          0.0342549
dummies.livestock(Intercept)            dummies.livestock.fYes
NA                                          0.0143253
dummies.own_land(Intercept)             dummies.own_land.fYes
NA                                          0.0396005
dummies.bicycle(Intercept)              dummies.bicycle.fYes
NA                                         -0.0047543
dummies.motorcycle_scooter(Intercept)   dummies.motorcycle_scooter.fYes
NA                                          0.0098133
dummies.animal_drawn_cart(Intercept)    dummies. animal_drawn_cart.fYes
NA                                         -0.0158127
dummies.cable_tv(Intercept)             dummies.cable_tv.fYes
NA                                         -0.0131543
dummies.generating_set(Intercept)       dummies.generating_set.fYes
NA                                          0.0270875
dummies.air_c(Intercept)                dummies.air_c.fYes
NA                                         -0.0457836
dummies.computer(Intercept)             dummies.computer.fYes
NA                                         -0.0344398
dummies.e_iron(Intercept)               dummies.e_irone.fYes
NA                                         -0.0086527
dummies.fan(Intercept)                  dummies.fan.fYes
NA                                         -0.0293364
no.na.data[["data.HV220"]]              no.na.data[["data.HV014"]]
0.0009463                                          0.0020138
```

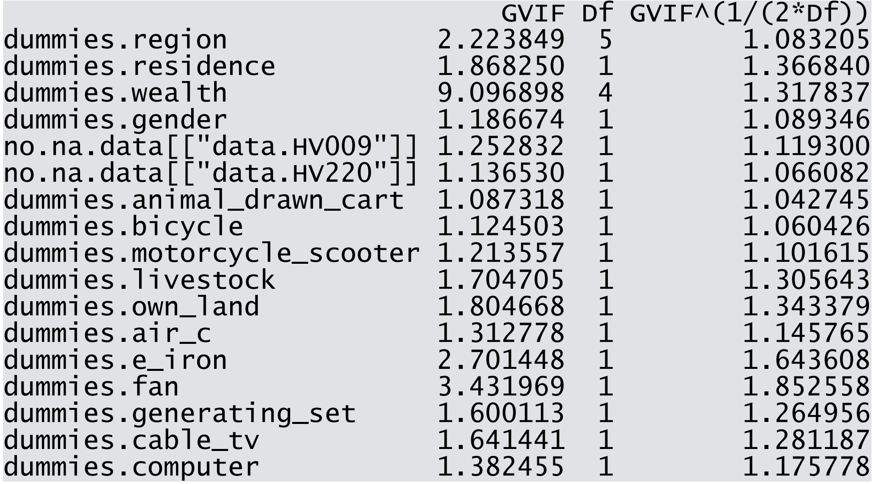
Appendix J: The percentage of NAs for *i* households across independent variables for DHS-VI 2013 and DHS-V 2008 for Nigeria

VI / 2013		V / 2008	
Independent variables	**NAs, %**	**Independent varibales**	**NAs, %**
Region	0	Region	0
Residence	0	Residence	0
Wealth	0	Wealth	0
Gender	0	Gender	0.003
HV009	0	HV014	0
HV220	0.17	HV220	0.30
Animal-drawn cart	0.58	Animal-drawn cart	0.41
Bicycle	0.55	Bicycle	0.35
Motorcycle/scooter	0.48	Motorcycle/scooter	0.37
Livestock	0.07	Livestock	0
Own land	0.08	Own land	0.1
Air conditioner	0.27	Air conditioner	0.26
Electric iron	0.16	Electric iron	0.2
Fan	0.17	Fan	0.19
Generating set	0.18	Generating set	0.23
Cable TV	0.31	Cable TV	0.33
Computer	0.27	Computer	0.29

Source: Author’s calculations derived from the Standard DHS data.

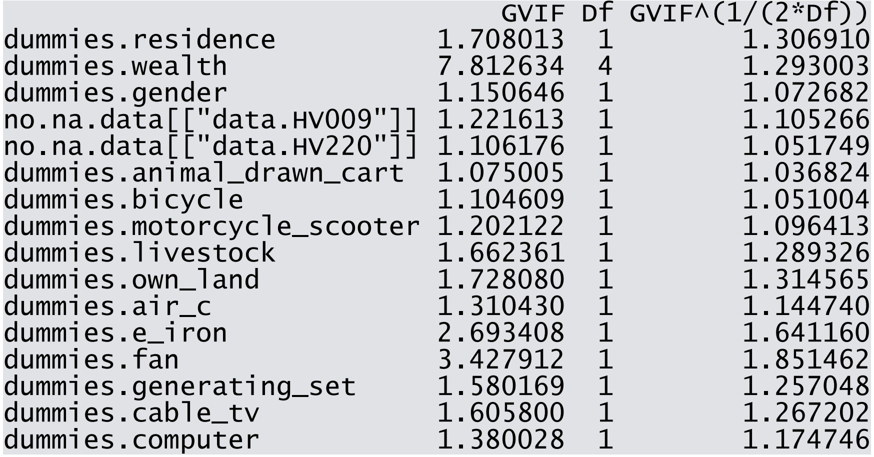
Appendix K: Test on Multicollinearity for DHS-VI 2013 and DHS-V 2008 for Nigeria

a) Including variable “region”, DHS-VI 2013



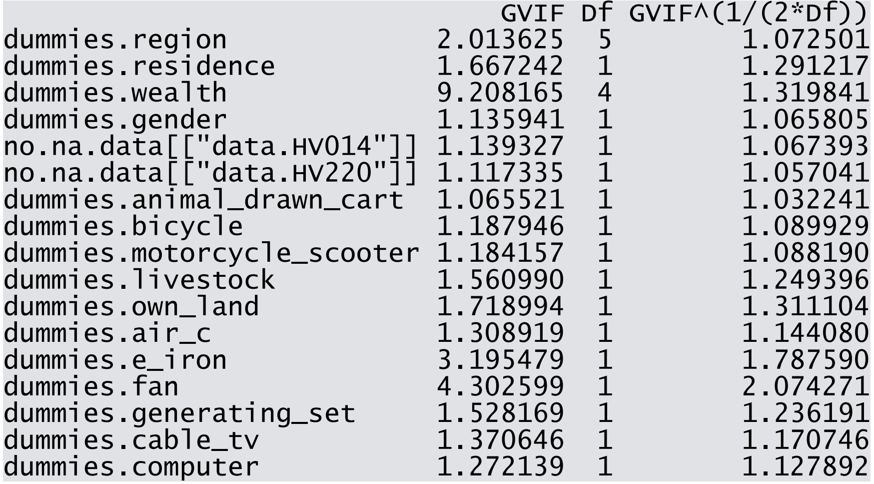
```
                                GVIF Df GVIF^(1/(2*Df))
dummies.region              2.223849  5        1.083205
dummies.residence           1.868250  1        1.366840
dummies.wealth              9.096898  4        1.317837
dummies.gender              1.186674  1        1.089346
no.na.data[["data.HV009"]] 1.252832  1        1.119300
no.na.data[["data.HV220"]] 1.136530  1        1.066082
dummies.animal_drawn_cart   1.087318  1        1.042745
dummies.bicycle             1.124503  1        1.060426
dummies.motorcycle_scooter  1.213557  1        1.101615
dummies.livestock           1.704705  1        1.305643
dummies.own_land            1.804668  1        1.343379
dummies.air_c               1.312778  1        1.145765
dummies.e_iron              2.701448  1        1.643608
dummies.fan                 3.431969  1        1.852558
dummies.generating_set      1.600113  1        1.264956
dummies.cable_tv            1.641441  1        1.281187
dummies.computer            1.382455  1        1.175778
```

b) Excluding variable “region”, DHS-VI 2013



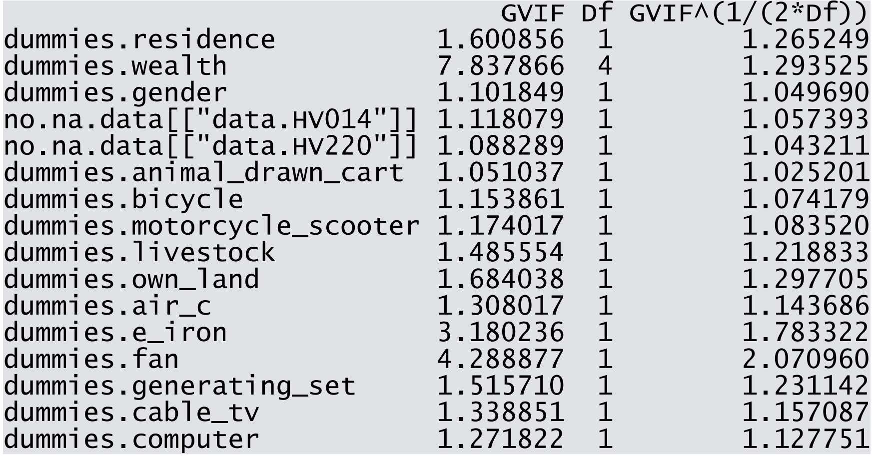
```
                                GVIF Df GVIF^(1/(2*Df))
dummies.residence           1.708013  1        1.306910
dummies.wealth              7.812634  4        1.293003
dummies.gender              1.150646  1        1.072682
no.na.data[["data.HV009"]] 1.221613  1        1.105266
no.na.data[["data.HV220"]] 1.106176  1        1.051749
dummies.animal_drawn_cart   1.075005  1        1.036824
dummies.bicycle             1.104609  1        1.051004
dummies.motorcycle_scooter  1.202122  1        1.096413
dummies.livestock           1.662361  1        1.289326
dummies.own_land            1.728080  1        1.314565
dummies.air_c               1.310430  1        1.144740
dummies.e_iron              2.693408  1        1.641160
dummies.fan                 3.427912  1        1.851462
dummies.generating_set      1.580169  1        1.257048
dummies.cable_tv            1.605800  1        1.267202
dummies.computer            1.380028  1        1.174746
```

c) Including variable “region”, DHS-V 2008



```
                                GVIF Df GVIF^(1/(2*Df))
dummies.region              2.013625  5        1.072501
dummies.residence           1.667242  1        1.291217
dummies.wealth              9.208165  4        1.319841
dummies.gender              1.135941  1        1.065805
no.na.data[["data.HV014"]] 1.139327  1        1.067393
no.na.data[["data.HV220"]] 1.117335  1        1.057041
dummies.animal_drawn_cart   1.065521  1        1.032241
dummies.bicycle             1.187946  1        1.089929
dummies.motorcycle_scooter  1.184157  1        1.088190
dummies.livestock           1.560990  1        1.249396
dummies.own_land            1.718994  1        1.311104
dummies.air_c               1.308919  1        1.144080
dummies.e_iron              3.195479  1        1.787590
dummies.fan                 4.302599  1        2.074271
dummies.generating_set      1.528169  1        1.236191
dummies.cable_tv            1.370646  1        1.170746
dummies.computer            1.272139  1        1.127892
```

d) Excluding variable “region”, DHS-V 2008

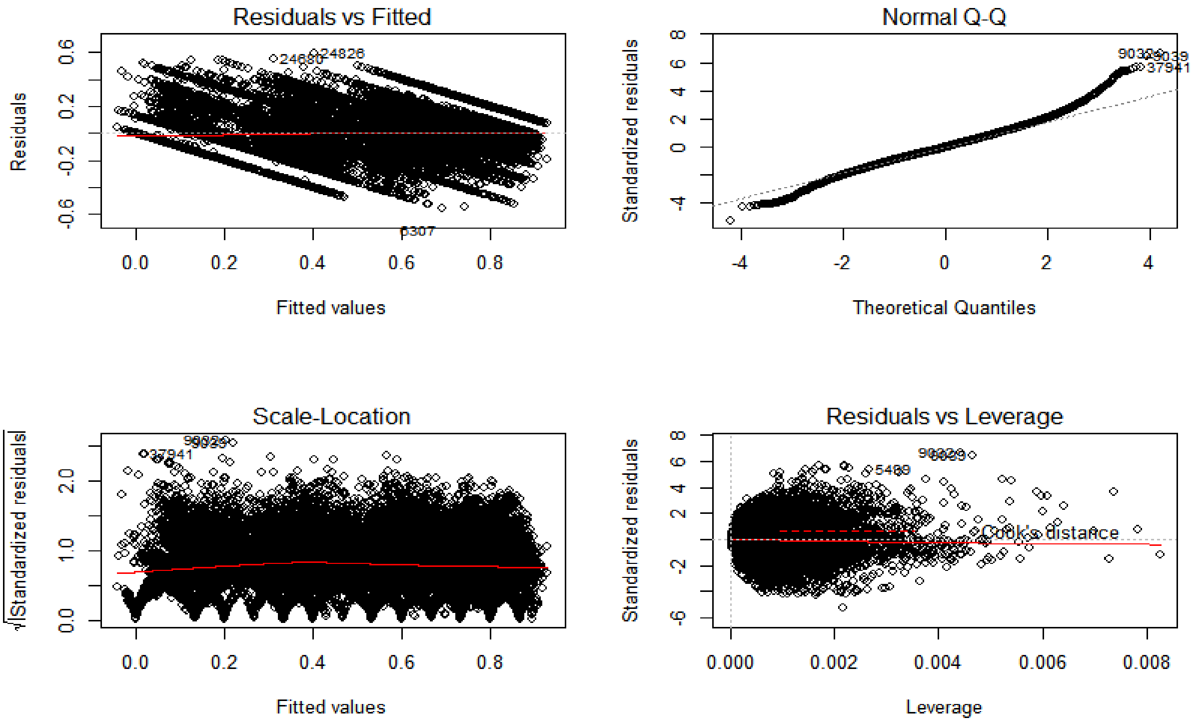


```
                                GVIF Df GVIF^(1/(2*Df))
dummies.residence           1.600856  1        1.265249
dummies.wealth              7.837866  4        1.293525
dummies.gender              1.101849  1        1.049690
no.na.data[["data.HV014"]] 1.118079  1        1.057393
no.na.data[["data.HV220"]] 1.088289  1        1.043211
dummies.animal_drawn_cart   1.051037  1        1.025201
dummies.bicycle             1.153861  1        1.074179
dummies.motorcycle_scooter  1.174017  1        1.083520
dummies.livestock           1.485554  1        1.218833
dummies.own_land            1.684038  1        1.297705
dummies.air_c               1.308017  1        1.143686
dummies.e_iron              3.180236  1        1.783322
dummies.fan                 4.288877  1        2.070960
dummies.generating_set      1.515710  1        1.231142
dummies.cable_tv            1.338851  1        1.157087
dummies.computer            1.271822  1        1.127751
```

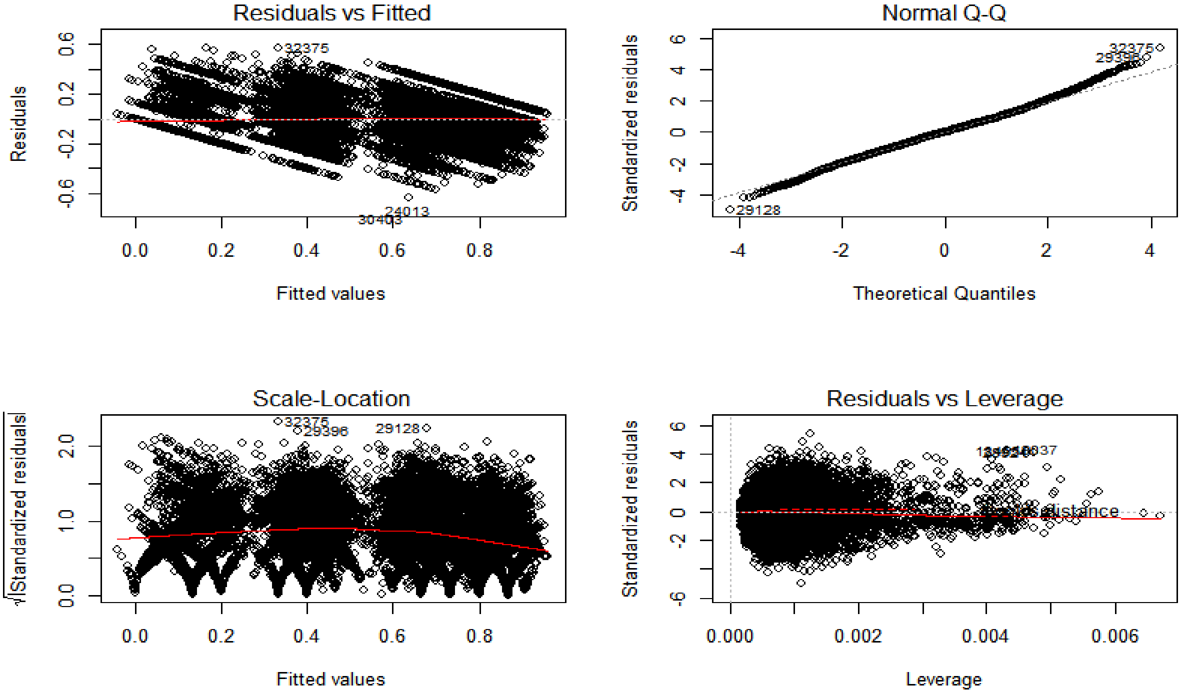
RStudio, Version 0.98.501 / Author: Olga Gordiievska / Creation Date: 20.07.2015

Appendix L: Diagnostic plots for the multiple regression analyses for DHS-VI 2013 and DHS-V 2008 for Nigeria

a) DHS-VI 2013



b) DHS-V 2008



RStudio, Version 0.98.501 / Author: Olga Gordiievska / Creation Date: 20.07.2015

Appendix M: Results of the multiple regression analyses for DHS-VI 2013 and DHS-V 2008 for Nigeria

##################
RStudio, Version 0.98.501
Author: Olga Gordiievska
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##################

a) Including variable “region”, DHS-VI 2013

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-796.54  -93.63   -4.53   92.37 1006.85 

Coefficients:
                                Estimate Std. Error t value Pr(>|t|)    
(Intercept)                    7.335e-01  4.802e-03 152.745  < 2e-16 ***
dummies.region.fNorth East     4.354e-02  3.076e-03  14.156  < 2e-16 ***
dummies.region.fNorth West    -4.864e-03  2.666e-03  -1.824 0.068097 .  
dummies.region.fSouth East    -5.109e-02  3.145e-03 -16.243  < 2e-16 ***
dummies.region.fSouth South   -6.523e-02  3.032e-03 -21.515  < 2e-16 ***
dummies.region.fSouth West    -9.906e-02  2.885e-03 -34.332  < 2e-16 ***
dummies.residence              3.628e-02  2.151e-03  16.867  < 2e-16 ***
dummies.wealthwealth.fPoorer  -6.138e-02  2.803e-03 -21.897  < 2e-16 ***
dummies.wealthwealth.fMiddle  -1.680e-01  3.158e-03 -53.195  < 2e-16 ***
dummies.wealthwealth.fRicher  -3.319e-01  4.237e-03 -78.339  < 2e-16 ***
dummies.wealthwealth.fRichest -5.296e-01  5.397e-03 -98.134  < 2e-16 ***
dummies.gender                 1.446e-02  2.182e-03   6.626 3.50e-11 ***
no.na.data[["data.HV009"]]    -9.104e-04  2.801e-04  -3.250 0.001154 ** 
no.na.data[["data.HV220"]]     9.638e-04  5.165e-05  18.659  < 2e-16 ***
dummies.animal_drawn_cart     -2.646e-02  4.351e-03  -6.081 1.21e-09 ***
dummies.bicycle               -6.021e-03  2.134e-03  -2.822 0.004782 ** 
dummies.motorcycle_scooter    -6.964e-03  1.852e-03  -3.759 0.000171 ***
dummies.livestock             -9.569e-03  2.035e-03  -4.702 2.58e-06 ***
dummies.own_land               2.574e-02  2.121e-03  12.136  < 2e-16 ***
dummies.air_c                 -5.091e-02  5.527e-03  -9.212  < 2e-16 ***
dummies.e_iron                -1.681e-02  2.719e-03  -6.185 6.29e-10 ***
dummies.fan                   -5.751e-02  2.898e-03 -19.843  < 2e-16 ***
dummies.generating_set         3.581e-02  2.267e-03  15.801  < 2e-16 ***
dummies.cable_tv              -3.548e-02  3.237e-03 -10.960  < 2e-16 ***
dummies.computer              -2.060e-02  4.299e-03  -4.793 1.65e-06 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 151.8 on 37932 degrees of freedom
Multiple R-squared:  0.753,	Adjusted R-squared:  0.7528 
F-statistic:  4817 on 24 and 37932 DF,  p-value: < 2.2e-16
```

b) Excluding variable “region”, DHS-VI 2013

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-697.62  -96.67   -4.88   94.72 1165.96 

Coefficients:
                                Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                    7.358e-01  4.150e-03  177.279  < 2e-16 ***
dummies.residence              3.841e-02  2.120e-03   18.118  < 2e-16 ***
dummies.wealthwealth.fPoorer  -7.407e-02  2.850e-03  -25.987  < 2e-16 ***
dummies.wealthwealth.fMiddle  -1.970e-01  3.083e-03  -63.917  < 2e-16 ***
dummies.wealthwealth.fRicher  -3.777e-01  4.154e-03  -90.923  < 2e-16 ***
dummies.wealthwealth.fRichest -5.939e-01  5.287e-03 -112.325  < 2e-16 ***
dummies.gender                 2.887e-03  2.215e-03    1.303 0.192459    
no.na.data[["data.HV009"]]     3.022e-04  2.851e-04    1.060 0.289138    
```

```
no.na.data[["data.HV220"]]      6.665e-04  5.253e-05   12.690  < 2e-16 ***
dummies.animal_drawn_cart      -1.329e-02  4.459e-03   -2.980 0.002882 ** 
dummies.bicycle                -4.708e-04  2.180e-03   -0.216 0.829015    
dummies.motorcycle_scooter     -1.218e-03  1.900e-03   -0.641 0.521649    
dummies.livestock              -4.768e-03  2.071e-03   -2.302 0.021357 *  
dummies.own_land                2.812e-02  2.139e-03   13.142  < 2e-16 ***
dummies.air_c                  -4.944e-02  5.691e-03   -8.687  < 2e-16 ***
dummies.e_iron                 -1.551e-02  2.798e-03   -5.545 2.96e-08 ***
dummies.fan                    -5.633e-02  2.985e-03  -18.867  < 2e-16 ***
dummies.generating_set          3.127e-02  2.322e-03   13.471  < 2e-16 ***
dummies.cable_tv               -1.469e-02  3.300e-03   -4.452 8.54e-06 ***
dummies.computer               -1.592e-02  4.427e-03   -3.597 0.000322 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 156.4 on 37937 degrees of freedom
Multiple R-squared:  0.7375,   Adjusted R-squared:  0.7374 
F-statistic:  5609 on 19 and 37937 DF,  p-value: < 2.2e-16
```

c) Including combined variable “region / gender”, DHS-VI 2013

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-776.86  -95.68   -5.29   94.33 1153.77 

Coefficients:
                                  Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                      7.337e-01  4.133e-03  177.511  < 2e-16 ***
dummies.gender_region.fFemale_NE 1.054e-01  7.462e-03   14.128  < 2e-16 ***
dummies.gender_region.fFemale_NW 4.067e-02  5.881e-03    6.915 4.75e-12 ***
dummies.gender_region.fFemale_SE 1.439e-02  4.164e-03    3.455 0.000552 ***
dummies.gender_region.fFemale_SS 8.008e-04  4.265e-03    0.188 0.851068    
dummies.gender_region.fFemale_SW-6.055e-02  3.763e-03  -16.091  < 2e-16 ***
dummies.residence                3.808e-02  2.133e-03   17.855  < 2e-16 ***
dummies.wealthwealth.fPoorer    -7.323e-02  2.828e-03  -25.895  < 2e-16 ***
dummies.wealthwealth.fMiddle    -1.932e-01  3.064e-03  -63.054  < 2e-16 ***
dummies.wealthwealth.fRicher    -3.704e-01  4.134e-03  -89.604  < 2e-16 ***
dummies.wealthwealth.fRichest   -5.845e-01  5.266e-03 -110.987  < 2e-16 ***
no.na.data[["data.HV009"]]       1.722e-04  2.830e-04    0.609 0.542858    
no.na.data[["data.HV220"]]       7.181e-04  5.212e-05   13.776  < 2e-16 ***
dummies.animal_drawn_cart       -1.261e-02  4.428e-03   -2.847 0.004411 ** 
dummies.bicycle                 -1.674e-03  2.166e-03   -0.773 0.439750    
dummies.motorcycle_scooter      -3.163e-03  1.885e-03   -1.678 0.093305 .  
dummies.livestock               -3.334e-03  2.063e-03   -1.616 0.106151    
dummies.own_land                 2.551e-02  2.147e-03   11.882  < 2e-16 ***
dummies.air_c                   -5.066e-02  5.652e-03   -8.964  < 2e-16 ***
dummies.e_iron                  -1.655e-02  2.779e-03   -5.955 2.62e-09 ***
dummies.fan                     -5.644e-02  2.965e-03  -19.036  < 2e-16 ***
dummies.generating_set           2.961e-02  2.307e-03   12.839  < 2e-16 ***
dummies.cable_tv                -1.965e-02  3.284e-03   -5.983 2.20e-09 ***
dummies.computer                -1.689e-02  4.396e-03   -3.842 0.000122 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 155.3 on 37933 degrees of freedom
Multiple R-squared:  0.7412,   Adjusted R-squared:  0.7411 
F-statistic:  4724 on 23 and 37933 DF,  p-value: < 2.2e-16
```

d) Excluding combined variable “region / gender”, DHS-VI 2013

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-694.16  -96.66   -4.85   94.61 1170.00 

Coefficients:
                                Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                    0.7360569  0.0041437  177.634  < 2e-16 ***
dummies.residence              0.0383556  0.0021195   18.097  < 2e-16 ***
dummies.wealthwealth.fPoorer  -0.0738077  0.0028433  -25.959  < 2e-16 ***
```

```
dummies.wealthwealth.fMiddle  -0.1965568  0.0030598  -64.237  < 2e-16 ***
dummies.wealthwealth.fRicher  -0.3771705  0.0041345  -91.226  < 2e-16 ***
dummies.wealthwealth.fRichest -0.5934570  0.0052780 -112.439  < 2e-16 ***
no.na.data[["data.HV009"]]     0.0002432  0.0002815    0.864 0.387530    
no.na.data[["data.HV220"]]     0.0006779  0.0000518   13.085  < 2e-16 ***
dummies.animal_drawn_cart     -0.0133169  0.0044591   -2.986 0.002824 ** 
dummies.bicycle               -0.0005660  0.0021789   -0.260 0.795039    
dummies.motorcycle_scooter    -0.0015780  0.0018800   -0.839 0.401261    
dummies.livestock             -0.0047086  0.0020709   -2.274 0.022993 *  
dummies.own_land               0.0279132  0.0021337   13.082  < 2e-16 ***
dummies.air_c                 -0.0495357  0.0056910   -8.704  < 2e-16 ***
dummies.e_iron                -0.0156059  0.0027971   -5.579 2.43e-08 ***
dummies.fan                   -0.0564171  0.0029846  -18.903  < 2e-16 ***
dummies.generating_set         0.0311820  0.0023206   13.437  < 2e-16 ***
dummies.cable_tv              -0.0147707  0.0032996   -4.476 7.61e-06 ***
dummies.computer              -0.0159477  0.0044268   -3.603 0.000316 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 156.4 on 37938 degrees of freedom
Multiple R-squared:  0.7375,   Adjusted R-squared:  0.7374 
F-statistic:  5921 on 18 and 37938 DF,  p-value: < 2.2e-16
```

e) Including variable “region”, DHS-V 2008

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-734.70  -96.89    0.29   94.84  796.61 

Coefficients:
                               Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                   7.497e-01  4.478e-03  167.421  < 2e-16 ***
dummies.region.fNorth East    5.642e-03  3.390e-03    1.664 0.096040 .  
dummies.region.fNorth West    1.079e-02  2.876e-03    3.753 0.000175 ***
dummies.region.fSouth East   -1.494e-02  3.228e-03   -4.627 3.72e-06 ***
dummies.region.fSouth South  -1.519e-02  3.049e-03   -4.982 6.32e-07 ***
dummies.region.fSouth West   -5.497e-02  2.918e-03  -18.834  < 2e-16 ***
dummies.residence             3.427e-02  2.166e-03   15.824  < 2e-16 ***
dummies.wealthwealth.fPoorer -6.548e-02  2.752e-03  -23.791  < 2e-16 ***
dummies.wealthwealth.fMiddle -1.764e-01  2.938e-03  -60.028  < 2e-16 ***
dummies.wealthwealth.fRicher -4.003e-01  4.240e-03  -94.417  < 2e-16 ***
dummies.wealthwealth.fRichest-6.322e-01  5.487e-03 -115.212  < 2e-16 ***
dummies.gender                2.562e-02  2.163e-03   11.843  < 2e-16 ***
no.na.data[["data.HV014"]]    2.033e-03  7.573e-04    2.684 0.007276 ** 
no.na.data[["data.HV220"]]    9.462e-04  5.195e-05   18.213  < 2e-16 ***
dummies.animal_drawn_cart    -1.621e-02  5.090e-03   -3.184 0.001454 ** 
dummies.bicycle              -4.681e-03  2.078e-03   -2.253 0.024277 *  
dummies.motorcycle_scooter    9.877e-03  2.030e-03    4.865 1.15e-06 ***
dummies.livestock             1.429e-02  2.005e-03    7.127 1.05e-12 ***
dummies.own_land              3.960e-02  2.160e-03   18.334  < 2e-16 ***
dummies.air_c                -4.568e-02  6.454e-03   -7.078 1.49e-12 ***
dummies.e_iron               -8.608e-03  3.051e-03   -2.821 0.004788 ** 
dummies.fan                  -2.944e-02  3.378e-03   -8.717  < 2e-16 ***
dummies.generating_set        2.707e-02  2.599e-03   10.412  < 2e-16 ***
dummies.cable_tv             -1.296e-02  4.456e-03   -2.908 0.003643 ** 
dummies.computer             -3.456e-02  5.546e-03   -6.232 4.67e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 147 on 33561 degrees of freedom
Multiple R-squared:  0.7886,   Adjusted R-squared:  0.7885 
F-statistic:  5217 on 24 and 33561 DF,  p-value: < 2.2e-16
```

f) Excluding variable “region”, DHS-V 2008

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-724.18  -97.35    2.45   96.43  760.67 
```

```
Coefficients:
                               Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                   7.487e-01  3.924e-03  190.801  < 2e-16 ***
dummies.residence             3.374e-02  2.143e-03   15.744  < 2e-16 ***
dummies.wealthwealth.fPoorer -7.362e-02  2.725e-03  -27.017  < 2e-16 ***
dummies.wealthwealth.fMiddle -1.897e-01  2.809e-03  -67.548  < 2e-16 ***
dummies.wealthwealth.fRicher -4.218e-01  4.069e-03 -103.661  < 2e-16 ***
dummies.wealthwealth.fRichest -6.642e-01  5.279e-03 -125.808  < 2e-16 ***
dummies.gender                2.316e-02  2.151e-03   10.769  < 2e-16 ***
no.na.data[["data.HV014"]]    3.695e-03  7.574e-04    4.878 1.08e-06 ***
no.na.data[["data.HV220"]]    7.887e-04  5.176e-05   15.237  < 2e-16 ***
dummies.animal_drawn_cart    -9.295e-03  5.104e-03   -1.821   0.0686 .  
dummies.bicycle               2.910e-03  2.067e-03    1.407   0.1593    
dummies.motorcycle_scooter    1.340e-02  2.041e-03    6.564 5.31e-11 ***
dummies.livestock             1.618e-02  1.975e-03    8.195 2.59e-16 ***
dummies.own_land              4.376e-02  2.158e-03   20.276  < 2e-16 ***
dummies.air_c                -4.405e-02  6.514e-03   -6.762 1.38e-11 ***
dummies.e_iron               -5.442e-03  3.073e-03   -1.771   0.0766 .  
dummies.fan                  -2.866e-02  3.405e-03   -8.418  < 2e-16 ***
dummies.generating_set        2.607e-02  2.614e-03    9.976  < 2e-16 ***
dummies.cable_tv              3.648e-03  4.446e-03    0.821   0.4119    
dummies.computer             -3.549e-02  5.599e-03   -6.338 2.35e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 148.5 on 33566 degrees of freedom
Multiple R-squared:  0.7845,   Adjusted R-squared:  0.7844 
F-statistic:  6431 on 19 and 33566 DF,  p-value: < 2.2e-16
```

g) Including combined variable “region / gender”, DHS-V 2008

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-750.74  -97.00    3.15   96.44  754.13 

Coefficients:
                                  Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                      7.487e-01  3.943e-03  189.853  < 2e-16 ***
dummies.gender_region.fFemale_NE 3.665e-02  8.926e-03    4.106 4.04e-05 ***
dummies.gender_region.fFemale_NW 3.685e-02  6.398e-03    5.760 8.49e-09 ***
dummies.gender_region.fFemale_SE 2.588e-02  4.042e-03    6.401 1.56e-10 ***
dummies.gender_region.fFemale_SS 3.777e-02  3.854e-03    9.799  < 2e-16 ***
dummies.gender_region.fFemale_SW-1.503e-02  3.745e-03   -4.014 5.98e-05 ***
dummies.residence                3.273e-02  2.145e-03   15.258  < 2e-16 ***
dummies.wealthwealth.fPoorer    -7.259e-02  2.726e-03  -26.629  < 2e-16 ***
dummies.wealthwealth.fMiddle    -1.879e-01  2.826e-03  -66.492  < 2e-16 ***
dummies.wealthwealth.fRicher    -4.193e-01  4.087e-03 -102.575  < 2e-16 ***
dummies.wealthwealth.fRichest   -6.606e-01  5.302e-03 -124.608  < 2e-16 ***
no.na.data[["data.HV014"]]       3.386e-03  7.561e-04    4.478 7.58e-06 ***
no.na.data[["data.HV220"]]       8.410e-04  5.194e-05   16.193  < 2e-16 ***
dummies.animal_drawn_cart       -9.156e-03  5.098e-03   -1.796   0.0725 .  
dummies.bicycle                  1.036e-03  2.069e-03    0.501   0.6167    
dummies.motorcycle_scooter       1.221e-02  2.040e-03    5.986 2.17e-09 ***
dummies.livestock                1.797e-02  1.986e-03    9.048  < 2e-16 ***
dummies.own_land                 4.173e-02  2.168e-03   19.251  < 2e-16 ***
dummies.air_c                   -4.422e-02  6.506e-03   -6.797 1.09e-11 ***
dummies.e_iron                  -6.024e-03  3.071e-03   -1.961   0.0499 *  
dummies.fan                     -2.950e-02  3.402e-03   -8.671  < 2e-16 ***
dummies.generating_set           2.504e-02  2.611e-03    9.588  < 2e-16 ***
dummies.cable_tv                 2.308e-03  4.444e-03    0.519   0.6035    
dummies.computer                -3.566e-02  5.592e-03   -6.377 1.83e-10 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 148.3 on 33563 degrees of freedom
Multiple R-squared:  0.785,    Adjusted R-squared:  0.7849 
F-statistic:  5329 on 23 and 33563 DF,  p-value: < 2.2e-16
```

h) Excluding combined variable “region / gender”, DHS-V 2008

```
Weighted Residuals:
    Min      1Q  Median      3Q     Max 
-705.61  -96.62    1.92   96.90  748.34 

Coefficients:
                                Estimate Std. Error  t value Pr(>|t|)    
(Intercept)                    7.516e-01  3.921e-03  191.694  < 2e-16 ***
dummies.residence              3.428e-02  2.146e-03   15.972  < 2e-16 ***
dummies.wealthwealth.fPoorer  -7.199e-02  2.725e-03  -26.417  < 2e-16 ***
dummies.wealthwealth.fMiddle  -1.865e-01  2.797e-03  -66.665  < 2e-16 ***
dummies.wealthwealth.fRicher  -4.185e-01  4.064e-03 -102.970  < 2e-16 ***
dummies.wealthwealth.fRichest -6.620e-01  5.285e-03 -125.275  < 2e-16 ***
no.na.data[["data.HV014"]]     2.733e-03  7.534e-04    3.627 0.000287 ***
no.na.data[["data.HV220"]]     8.499e-04  5.154e-05   16.491  < 2e-16 ***
dummies.animal_drawn_cart     -1.056e-02  5.112e-03   -2.065 0.038890 *  
dummies.bicycle                1.969e-03  2.069e-03    0.951 0.341382    
dummies.motorcycle_scooter     1.066e-02  2.029e-03    5.255 1.49e-07 ***
dummies.livestock              1.592e-02  1.978e-03    8.050 8.56e-16 ***
dummies.own_land               4.201e-02  2.156e-03   19.487  < 2e-16 ***
dummies.air_c                 -4.346e-02  6.525e-03   -6.661 2.77e-11 ***
dummies.e_iron                -5.911e-03  3.078e-03   -1.920 0.054835 .  
dummies.fan                   -2.950e-02  3.410e-03   -8.652  < 2e-16 ***
dummies.generating_set         2.530e-02  2.617e-03    9.665  < 2e-16 ***
dummies.cable_tv               3.021e-03  4.453e-03    0.678 0.497523    
dummies.computer              -3.664e-02  5.608e-03   -6.533 6.54e-11 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Residual standard error: 148.7 on 33568 degrees of freedom
Multiple R-squared:  0.7838,	Adjusted R-squared:  0.7836 
F-statistic:  6759 on 18 and 33568 DF,  p-value: < 2.2e-16
```

CURRICULUM VITAE

OLGA GORDIIEVSKA

Date of birth: 26.11.1985
Place of birth: Cherkassy, Ukraine

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WORK EXPERIENCE

05.11.2011- current	**Consultant at the Energy Branch/Office of the Director** Programme Development and Technical Cooperation Division *United Nations Industrial Development Organization (UNIDO)* Vienna International Centre
11.04.2011- 05.08.2011	**Intern at the Energy Branch/Industrial Energy Efficiency Unit** Programme Development and Technical Cooperation Division *UNIDO* Vienna International Centre
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EDUCATION

01.10.2008 - current	*University of Vienna, Austria* **Master of Science, International Business Administration** Specialization: International Management; Energy and Environmental Management
01.09.2007-30.06.2008	*Vadym Hetman Kyiv National Economic University, Ukraine* **Master, International Economics and Management** Specialization: European Integration
14-29.08.2008	Alpbacher Sommerschule für Europäische Integration 2008, Austria **Seminar on Law of the European Union**
21-25.04.2008	*Vadym Hetman Kyiv National Economic University and LONDON Metropolitan University* **Certificate, Training program “Sector Policies of European Union”**
30.07.2007-18.08.2007	18th International Summer University 2007, Austria **Certificate, Strategic Management of Enterprises and International Human Resource Management**
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