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Research article

Towards the attainment of sustainable development goal 7: what determines clean energy accessibility in sub-Saharan Africa?

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Abstract: Access to clean energy is necessary for environmental cleanliness and poverty reduction. That notwithstanding, many in developing countries especially those in sub-Saharan Africa region lack clean energy for their routine domestic activities. This study sought to unravel the factors that influence clean energy accessibility in sub-Saharan Africa region. Clean energy accessibility, specifically access to electricity, and access to clean cooking fuels and technologies, were modeled as a function of income, foreign direct investment, inflation, employment and political regime for a panel of 31 sub-Saharan countries for the period 2000–2015. Regression analysis from fixed effect, random effect and Fully Modified Ordinary Least Squares show that access to clean energy is influenced positively by income, foreign direct investment, political regime and employment while inflation has some negative effect on its accessibility. The policy implications from the findings among other things include that expansion in GDP per capita in the sub-region shall be helpful in increasing accessibility to clean energy. Moreover, strengthening the democratic institutions of countries in the region shall enhance the citizens' accessibility to clean energy. Ensuring sustainable jobs for the citizens is necessary for access clean energy.

Keywords: clean energy; sustainable development goals; sub-Saharan Africa; energy accessibility

JEL Codes: Q0, Q31, Q40, Q41, Q42, Q43

1. Introduction

Low carbon economy has become a much talked about issue in recent times. This is as a result of the devastating effect of climate change on economic livelihoods and ecosystem. The use of energy especially fossil fuel, scholars have maintained, is associated with greater emissions of carbon dioxide (Churchill et al., 2021). In this light fossil fuel is acknowledged as a major source of the problem of climate change. This has led to a campaign for energy management (Moktadir et al., 2019; Kwakwa, 2021) and the promotion, development, accessibility and usage of clean energy (Simionescu et al., 2021; Adom and Kwakwa, 2019). Having access to cleaner energy is among other things crucial for economic growth, improved health and improved gender empowerment aside the environmental benefit (Kwakwa and Adusah-Poku, 2019; Churchill et al., 2021). Consequently, global investment in renewable energy technologies, which are clean energy sources, has increased over the past years. Similarly, the global usage of clean energy has seen an upward trend. Between 2010 and 2019, a report by the United Nations Environment Programme (UNEP)[1] shows that globally, an amount of US$2.6tn was invested in renewable energy (excluding large hydro). This figure was three times the amount spent between 2001 and 2009. In addition, the report revealed that in 2018 the global investment in renewable energy capacity of US$272.9bn was thrice the amount invested in coal and gas-fired generation capacity. Also, there was a 10% increment in the amount for research and development of renewable energy. It is not only the investment in renewable energy which has increased in the course of time. Over the past decade, the rise in the consumption of renewable energy is appreciable. For instance, between 2005 and 2015, the share of global renewable energy in total final energy consumption rose from 17.04% to 18.05% (World Bank, 2020). In 2018 alone, there was a 4% increase in the consumption of renewables, which accounted for about a quarter of the growth in global energy demand (International Energy Agency, IEA, 2019). In that same period, the share of modern renewable energy rose to 11% with electricity generation from renewable which forms more than one-quarter of total generation, accounting for 56% of the increase in renewable energy use since 2000 (IEA, 2020a). The IEA (2020b) further shows that compared to the first quarter of 2019, global use of renewable energy in all sectors increased by about 1.5% for the first quarter 2020.

However, there remains a wide disparity in the accessibility of clean energy among various regions of the world. While accessibility is high for America and European countries, African countries especially those in the sub-Saharan Africa (SSA) region have the lowest rates of clean energy accessibility. This casts doubts on the sub-region's ability to meet the United Nations Sustainable Development Goal (SDG 7). The SDG 7 aims at achieving global access to affordable, reliable, sustainable and modern energy by 2030. It also seeks to increase renewable energy's share in the global energy mix, improve energy efficiency by 100%, and to expand infrastructure and improve technology for supplying modern and sustainable energy by 2030. To gear towards the attainment of SDG 7 and thus avoid a fiasco, it is necessary to unearth the underlying factors responsible for such disparities among countries and regions mentioned above. A key approach to resolve this is to focus on the drivers of clean energy accessibility. Consequently, this study investigates the determinants of clean energy accessibility in sub-Saharan Africa region. The sub-Saharan Africa region is endowed with natural

[1]wedocs.unep.org/bitstream/handle/20.500.11822/29752/GTR2019.pdf?sequence=1&isAllowed=y.

resources that can be tapped to generate energy for use. However, a large number of people on the continent lack access to clean energy. At the household level, reliance on charcoal, firewood and dirty fossil fuel based energy is a feature of the continent. The region has the lowest clean energy access rates in the world. For instance, while only about half of the people in the sub-region can access electricity, only one-third can access clean cooking. Thus, the sub-region has about 600 million people that lack electricity and 900 million that cook with traditional fuels (IEA, 2019). It is also forecasted that about 50% of the world's population that may lack access to clean cooking in 2040 will be from the African continent (IEA, 2019).

The sub-region's renewable energy share of total energy consumption has not seen much improvement. For instance, renewable energy share of total energy consumption has been fluctuating between 70–72% over the past 10 years (World Bank, 2020). Thus, sub-Saharan Africa may not just be unable to achieve the UN Sustainable Development Goals (SDG 7) but also other related goals like SDG 3 (good health and well-being), SDG 12 (sustainable consumption and production), SDG 13 (climate action) and SDG 15 (Life on land) by 2030. It is therefore not surprising that many of the reported cases of diseases in the sub-region are air-pollution related. If the renewable energy share in total energy consumption has not seen massive improvement and accessibility to clean energy is low, then one would expect rising levels of carbon dioxide emissions. Although the sub-region's contribution to the global carbon dioxide emission is very small compared to other continents, there has been a tremendous increase in the emission of carbon dioxide between 1960 and 2016 from over 9.2 million kt to 33.8 million kt (World Bank, 2020). This raises concern for policymakers and researchers since the sub-region is severely hit by the effects of climate change. It therefore stands to reason that more clean energy should be used. It is in this light that the governments in the region have shown commitment to increase the share of renewable energy in recent times as found in various governments' policy documents. The success of such efforts would require knowledge on the determinants of clean energy accessibility for the sub-region. However, empirical studies to unravel such outcomes are limited. The closest studies are those that have explored the driving forces of renewable energy consumption (Ackah and Kizys, 2015; Ergun et al., 2019; Kwakwa, 2020). Since the two issues of renewable energy consumption and access to clean energy are not technically the same and may have different implications, this study analyzed the determinants of clean energy accessibility in sub-Saharan Africa region. Specially, it examined the effect of income, inflation, foreign direct investment, employment and political regime on clean energy access in the sub region.

The contribution of this work to the literature is threefold. To the best of our knowledge it is the first to do an econometric analysis of the drivers of clean energy accessibility in Africa. A growing number of studies have investigated energy related issues in Africa including energy consumption/intensity factors (Kwakwa et al., 2018; Keho, 2016; Kwakwa, 2017; Kwakwa, 2018a; Adom, 2015). However, none has assessed clean energy accessibility at the regional level. It also examines the effect that political regime may have on clean energy accessibility. Recently, the role of political regime and other institutions in the energy-environmental quality literature has gained prominence. Although some empirical studies (Ibrahim and Law, 2016; Adams et al., 2016; Kwakwa, 2019; Hassan et al., 2020) have explored how institutional quality including political regime affect energy consumption and environmental quality, no study has yet worked on the effect of institutional quality especially political regime on clean energy accessibility. This analysis done in this study is significant since democracy has been gaining grounds gradually in the sub-region. It is however empirically unclear how such development is affecting clean energy accessibility on the continent. Third, some micro studies have revealed driving forces of household's choice of clean cooking fuels and electricity access in certain parts of Africa (Aminu, 2015; Ogwumike et al., 2014; Mensah and Adu, 2015; Karimu et al., 2016). Since such evidences are fragmented and do not provide a one spot evidence, a panel approach to the analysis which gives a general picture is employed in this study.

The rest of the paper is structured as follows. The next section reviews related studies. Section 3 details the data and empirical approach. In section 4, the generated results are presented and discussed. Finally, section 5 provides concluding remarks with policy recommendations.

2. Brief Literature review

Access to modern energy services such as electricity and clean cooking fuels is a persistent challenge to many developing countries, especially countries within the Sub-Saharan African (SSA) region. Access to electricity and access to clean cooking fuels are subsets of a bigger concept which has come to be known as "energy poverty". Energy poverty can be measured using access to electricity, and access to modern and clean cooking fuels such as electricity and liquefied petroleum gas (LPG). Using this measure as a proxy for energy poverty reveals the existence of substantial energy poverty challenges, particularly in SSA. As such, studies have attempted to understand the factors explaining the low levels of access to electricity and access to clean cooking fuels that characterize many developing countries, particularly in SSA. These studies have been conducted either at the household level or at the country level.

At the household level, factors such as household income, fuel prices, education level of household head, household size and gender of the household head drive household's choice of clean cooking fuels and electricity access (Das et al., 2014; Aminu, 2015; Paudel et al., 2018; Özcanet al., 2013; Ogwumike et al., 2014; Mensah and Adu, 2015; Karimu et al., 2016; Kwakwa et al., 2013). These studies acknowledge that the choice of a clean cooking fuel display some characteristics of a normal good as their uptake and consumption increases with income. Also, the choice of a clean cooking fuel depends on the location of the household as urban households are more likely to choose and use a clean cooking fuel compared to rural households. These studies also highlight the importance of education in the choice of clean cooking fuels as higher education tends to inform households about the advantages of using clean cooking fuels as opposed to the high opportunity costs and health risks associated with the use of solid cooking fuels.

At the country level, most of the studies are on electricity rather than on cooking fuels. In fact, even on electricity, most of these studies tend to focus more on the demand side as many researchers point out that demand-side challenges are as much or more of an obstacle to increasing electrification than supply-side challenges (Low et al., 2008; Al-Bajjali et al., 2018; Adom et al., 2012; Adom and Bekoe, 2013; Ziramba, 2013; Inglesi-Lotz and Pouris, 2016; Ekpo et al., 2011; Asumadu-Sarkodie and Yadav, 2019; Poloamina et al., 2013; Kwakwa, 2018b). Some of the factors identified to influence electricity demand by these studies include income, electricity price, urbanization, income inequality and the economic structure of the country. Electricity price is a key predictor of electricity demand especially in SSA. The reason being that, the unit cost of electricity to consumers in most countries within the SSA region is far higher than in many emerging economies. Another significant factor constraining electricity consumption is affordability as many households in SSA are not able to afford connection fees and usage tariffs.

With regards to clean cooking fuels at the country level, there exists scanty studies. In fact, our literature search indicates that this is the first study to conduct an econometric analysis on clean energy accessibility in SSA combining access to electricity, and access to clean cooking fuels and technology in the same work. The focus on both access to electricity, and access to clean cooking fuels and technology in SSA will help in speeding up efforts by SSA countries in their quest to meet goal seven of the Sustainable Development Goals (SDGs) which is to ensure universal access to affordable, reliable, sustainable and modern energy by the year 2030.

Most developing countries, especially within the sub-Saharan Africa region have not yet attained 100 percent electrification rate. This is because some communities, particularly in the rural areas are yet to be connected to the grid. Electricity infrastructure requires huge investments which would demand funds from various sources. One of such sources is foreign direct investment (FDI), which is a measure of financial development. Very few authors have examined the relationship between FDI and access to electricity. D'Amelio et al. (2016) examined the relationship between FDI and access to electricity in developing countries, particularly in local communities within the sub-Saharan Africa region. The authors concluded that FDI indeed promotes access to electricity even in the midst of weak regulatory institutions. Other studies such as Kinda (2010) assert that the lack of robust infrastructure, including electricity infrastructure in developing countries tends to discourage FDI. Zhang et al. (2019) in their attempt to examine the relationship between access to electricity and socio-economic factors in developing countries found a long-run relationship between financial development and electricity access. The conclusion from these studies is that FDI could be relied on as an important source of finance to accelerate the process of achieving universal access to electricity in developing countries, particularly in sub-Saharan Africa. With regards to the link between FDI and access to clean cooking fuels, empirical literature on it is barely existent. It is also our assertion that one of the channels to scale up investments in clean cooking fuels and technology is by FDI and conducting empirical studies on the link between FDI and access to clean cooking fuels could support this assertion and subsequently fill the gap in the literature in this respect.

To conclude, the review of related literature has shown that there is scarcity of empirical works on the drivers of (aggregate) clean energy accessibility in Africa at the regional level. Since these existing ones provide a fragmented evidence from different parts of the sub region, a panel analysis as an approach to unravel a snapshot of the drivers of clean energy accessibility becomes necessary for effective policymaking and it is needed to be embarked upon. The role of political regime in promoting clean energy accessibility has also not been given attention in the empirical works. These identified gaps in the literature are bridged in this paper.

3. Data and methods

This section presents the methodology and data used to achieve the objectives of the study. The section is divided into three sub-sections. The first sub-section describes the theoretical and empirical modelling followed by the sources of data. This section ends with the estimation techniques employed to estimate the model contained in the first sub-section.

3.1. Theoretical and empirical modelling

The theoretical model for this study is based on the traditional theory of demand. We assume that clean energy is a commodity that countries choose from a pool of other forms of energy. We also consider clean energy as an indirect form of energy as it is generally demanded for the satisfaction countries derive from its use. Following from the traditional theory of demand, clean energy as a commodity is assumed to be mainly determined by income and price. This is mathematically expressed in Equation (1) as:

$$\boldsymbol{CEA_{it}} = \alpha_0 + \alpha_1 X_{1t} + \alpha_2 X_{2t} \tag{1}$$

where $\boldsymbol{CEA_{it}}$ is clean energy accessibility for country i at time t, X_1 represents price, X_2 represents income, α_1 represents the coefficient of price and α_2 represents the coefficient of income. Price is expected to have an inverse relationship with clean energy accessibility. The rationale has been that a higher price increases the opportunity cost of clean energy which reduces the quantity of clean energy that is bought and consumed. Assuming clean energy is a normal good, then it is expected that there would be a direct relationship between income and access to clean energy. All others things held constant, an increase in a country's income level is expected to increase household incomes which induces the households to opt for clean energy. As clean energy is known to be expensive, its demand will be influenced significantly by higher incomes. In fact, recent studies including Matei (2017), Simionescu et al. (2020) and Churchill et al. (2021) reported that income positively affect cleaner energy consumption.

Arguments have also been put up for the role of employment in the uptake of clean energy. Studies such as Twumasi et al. (2020) and Adusah-Poku and Takeuchi (2019) found that employment has a positive and significant effect on the adoption of clean energy. These studies suggest that employment increases the incomes of households enhancing their ability to afford clean energy. Although these studies were conducted at the household level, it is easier to translate these results at the national level and expect that a higher employment rate at the country level induces the uptake of clean energy. As such, an employment variable is added to the clean energy function to assess its impact on clean energy accessibility.

The role of political regimes of countries have also been explored in studies on energy demand, energy consumption and energy efficiency (Lu et al., 2021). Studies such as Uzar (2020), Cary (2019), Sun et al. (2019), Sarkodie and Adams (2018) and Shah et al. (2020) found a positive and significant relationship between a country's democratic political regime and the uptake of clean fuels and renewable energy, vis-à-vis the quality of institutions. These studies argue that the quality of institutions significantly depends on the political regime of a country and as such, plays a significant role in the quest to mitigate the factors of climate change and its impact. As plans are being put in place to mitigate climate change, access to clean energy is encouraged to reduce environmental degradation. It is in view of this that this study includes a political regime variable to examine its impact on clean energy accessibility in SSA.

Clean energy, although recommended by all is expensive at least at the initial stage. To extend electricity to all parts of a developing country and to ensure that every citizen in a country has access to electricity requires huge capital and investment. Same can be said of clean cooking fuels and technology. As such, various financing options have to be explored to ensure an increase in access to electricity and clean cooking fuels. To account for this, we include FDI in the clean energy equation to assess its impact on clean energy accessibility.

Based on the aforementioned empirical studies and arguments on this subject, Equation (1) is augmented to include other key variables namely employment, FDI and political regime. Consequently, the study augments the model in Equation (1) which is now specified in Equation (2) and Equation (3) to reflect the effect of income, inflation (proxy for price), employment, FDI and political regime on clean energy accessibility as:

$$\boldsymbol{CEA} = f(\boldsymbol{Y, INF, EMP, POLI, FDI}) \tag{2}$$

$$\boldsymbol{CEA_{it}} = f(\boldsymbol{Y_{it}^{\beta_1}}, \boldsymbol{e^{INF_{it}^{\beta_2}}}, \boldsymbol{e^{EMP_{it}^{\beta_3}}}, \boldsymbol{e^{POLI_{it}^{\beta_4}}}, \boldsymbol{FDI_{it}^{\beta_5}}) \tag{3}$$

where **CEA** represents clean energy accessibility, **Y** represents income, **INF** represents inflation, **EMP** represents employment, **POLI** represents political regime, **FDI** represents Foreign Direct Investment, *i* is the country and *t* is the time. Equation (3) can be further expanded after transforming into natural logarithm as:

$$CEA_{it} = \beta_0 + \beta_1 Y_{it} + \beta_2 INF_{it} + \beta_3 EMP_{it} + \beta_4 POLI_{it} + \beta_5 FDI_{it} + \eta_1 + \varepsilon_{it} \tag{4}$$

where ε is the independent and identically distributed error term and η_i is the unobserved country-specific effect. Inflation is used to proxy price because of the nature of our dataset. Every country in our sample uses different electricity pricing technique making it difficult for comparison. Also, prices for clean cooking fuels and technologies for our sampled countries are not available and as such, inflation could be a good proxy for the prices of electricity and clean cooking fuels and technologies.

3.2. Sources of data and data description

Our study uses data from two main secondary sources. All variables with the exception of the political regime variable were retrieved from the World Bank's World Development Indicators (2020). Data on political regime were retrieved from the Polity IV project[2]. The study uses an unbalanced panel data covering 31 sub-Saharan countries[3]. Data covers the period, 2000–2015 and the period selection is based solely on data availability of the variables of interest. CEA is proxied by two main variables: access to electricity (log of number of people with access to electricity) and access to clean cooking fuels and technologies (% of population). Y is proxied by log of GDP per capita (constant US Dollars) while EMP is proxied by the employment-population ratio. FDI which represents the level of financial development in a country is measured using log of FDI net inflows in current US dollars. The

[2]https://www.systemicpeace.org/inscrdata.html.

[3] Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroun, Comoros, Congo, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Togo and Uganda.

use of FDI as a measure of financial development is because of the close relationship between FDI and financial development. The argument made is that FDI provides a major funding source for projects to be executed in many developing countries. As a country receives more FDI its financial sector therefore tends to improve. Some authors have equally regarded FDI as a measure of a country's financial development (Twereofu et al., 2016). POLI is used to measure political regime which is an index of democratization (It ranges between −10 to 10 where 10 is strong democracy and −10 is strong autocracy) and INF is measured by consumer prices (annual %).

3.3. Estimation techniques

First, we examine whether there is the presence of cross-sectional dependence (CD) among the variables. Such a confirmation is necessary to determine the kind of unit root test to use. In this study the Pesaran CD test is used to assess the cross-sectional independence of the variables. Based on the outcome we examine the stationarity properties of the variables in the model. In the presence of cross-sectional dependence, the first-generation unit root test such as Im, Pesaran, and Shin (2003) panel unit root test and the second generation Maddala and Wu (1999) panel unit root test would not be ideal. If the contrary is the case the second generation Pesaran (2007) Panel Unit Root test (cross-sectionally augmented IPS, CIPS) is appropriate. Next, we determine the cointegration relationship between the variables using two panel cointegration tests developed by Pedroni (1999). The study employs three different approaches to estimate our main model in Equation (3): Fixed effect (FE), Random effect (RE) and the Fully Modified Ordinary Least Squares (FMOLS). The use of FE and RE has several advantages such as allowing the derivation of efficient estimators that make use of both within and between group variation. RE in particular allows the estimation of the impact of time-invariant variables. FMOLS is noted for its ability to deal with potential endogeneities and is robust to serial correlation problems. It also provides consistent and efficient estimates even in the absence of cointegration (Amuakwa-Mensah et al., 2017). It is the above mentioned reasons that compelled the study to employ there regression techniques.

4. Results and discussion

In this section, the results of estimations are presented followed by a discussion thereafter. Prior to that the descriptive statistics and correlation among the variables are presented.

Table 1. Descriptive statistics of variables.

Statistics	Clean fuel technology	EMP	FDI	INF	Y	POLI	Electricity
Mean	14.03185	63.99628	18.76061	8.119459	6.810079	3.221030	14.27527
Median	3.075000	65.95800	18.90471	5.640971	6.612079	5.000000	14.22088
Maximum	92.94000	87.81800	22.90268	112.6936	9.119849	10.00000	18.41541
Minimum	0.150000	39.88300	10.36072	−29.69107	5.323361	−7.000000	5.700444
Std. Dev.	21.89253	13.44672	2.066739	12.62364	0.910426	4.869972	1.671325
Observations	466	466	466	466	466	466	466

From Table 1, the mean employment for the sub region is 63.99% within the study period. Its maximum and minimum figures are 87.81% and 39.88% respectively. While political regime also has a mean of 3.22 suggesting the sub region has had a weak democracy within the period (although there is a maximum figure of 10), inflationary rate has been moderate with a mean of 8.11%. Access to clean fuel and technology has a mean of 14.03% and that of electricity is 14.27% indicating that access to electricity appears to be higher than the clean fuel and technology.

Table 2. Correlation results among variables.

Correlation	Clean fuel technology	EMP	FDI	INF	Y	POLI	Electricity
Clean fuel technology	1.000000						
EMP	−0.505588	1.000000					
FDI	0.095667	0.009280	1.000000				
INF	−0.135684	0.061007	6.38E−05	1.000000			
Y	0.753569	−0.500469	0.302617	−0.133527	1.000000		
POLI	0.391222	−0.178642	−0.061752	0.004021	0.161409	1.000000	
Electricity	−0.109627	0.077584	0.563614	0.039929	0.168659	−0.087723	1.000000

The correlation results in Table 2 shows that generally there is no tendency for some of the variables to cause the problem of multicollinearity since the degree of association between any two of the explanatory variables is not exactly one. There is however a positive correlation among all the explanatory variables except between employment and inflation, employment and political regime, and that of FDI and political regime. With the exception of employment and inflation the explanatory variables have positive association with access to clean fuel technology. On the other hand, while only political regime correlate with access to electricity negatively the other explanatory variables correlate with electricity positively.

4.1. Cross sectional dependence and Unit Root Test

The results provided in Table 3 show that the p-value of the CD test statistic exceeds 5%, which implies the absence of Cross-sectional Dependence. As a result, we employ the Im, Pesaran and Shin

(IPS) test (Im et al., 2003) and the Maddala and Wu (1999) test to verify the stationarity properties of the data. The results of the stationarity tests are presented in Table 3. The IPS test results show that inflation and political regime are stationary at levels, while other variables are stationary after first difference. The results from the Maddala and Wu test also show all the variables are stationary at level. Overall, stationarity is established either at levels or at first difference for all variables and hence the variables are appropriate for regression estimations with the assurance that these regressions will not generate spurious results.

Table 3. Cross sectional dependence and Unit root test results.

Cross sectional dependence test			
	Statistic		Prob
Pesaran CD (Clean fuels & tech model)	−0.7761		0.4377
Pesaran CD (Electricity model)	0.7739		0.4390
	IPS Unit root test		Maddala and Wu Unit root test
	Levels	First difference	Levels
Access to fuels and technology	8.1650	−5.1960***	106.695***
Access to electricity	3.0999	−13.4336***	298.369***
Income	2.9872	−6.2556***	135.265***
Employment	1.5327	−2.2308**	82.286**
Political regime	−2.8E+13***	8.2030***	263.872***
Inflation	−7.2140***	−13.5981***	469.854***
FDI	−0.1899	−7.6344***	92.45***

Note: *** and ** denote 1% and 5% levels of significance respectively.

4.2. Panel cointegration

Following the establishment of stationarity of the variables, we performed tests of cointegration. This is necessary because even if variables in a model do not satisfy stationarity properties, their linear combination in a model could be stationary. We use the cointegration tests to ascertain whether a stable equilibrium relationship exists between the dependent variables and the explanatory variables in the long run. The results of the Pedroni cointegration tests are presented in Table 4. Pedroni's multiple test statistics for cointegration allow for heterogeneity. In the access to clean fuels model, four of the test statistics reject the null hypothesis of no cointegrating relationship while in the access to electricity model, three of the test statistics reject the null hypothesis of no cointegration. Thus, the overall results provide some degree of evidence of the potential existence of a long run equilibrium relationship among the variables. In other words, the variables tend to move together in the long run.

Table 4. Cointegration test results.

		Clean fuels model		Electricity model	
		Statistic	Weighted Statistic	Statistic	Weighted Statistic
Pedroni tests	Panel v-Statistic	79.4086***	9.4139***	2.1417**	−3.9776
	Panel rho-Statistic	5.7642	4.6576	2.8554	2.9202
	Panel PP-Statistic	0.5758	−7.3861***	−0.4710	−1.4020***
	Panel ADF-Statistic	3.7105	0.5352	1.0774	1.0057
	Group rho-Statistic	7.0935		4.8843	
	Group PP-Statistic	−8.9806***		−1.7339**	
	Group ADF-Statistic	−1.0660		1.1712	

Note: *** and ** denote 1% and 5% levels of significance respectively.

Following the establishment of cointegration, we proceeded to estimate the long run relationships between access to clean fuels and technology for cooking, and access to electricity and the respective explanatory variables. In addition to the fixed effect (FE) and random effect (RE) models, we also estimated the fully modified OLS (FMOLS). The results reported in Table 5 and Table 6 reveal similar outcome in terms of sign and significance from the regression results. Again, the results from the estimation techniques appear similar for each of the model. Table 5 shows the results for access to clean fuels and technology model while Table 6 shows the results for access to electricity model.

Table 5. Regression results for access to clean fuels and technology.

	Fixed effect		Random effect		FMOLS	
Variable	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Income	9.2763***	0.7528	9.9728***	0.7294	9.1682***	0.0132
Employment	0.3434***	0.0501	0.2934***	0.0485	0.3283***	0.0126
Political regime	0.2624***	0.0567	0.2634***	0.0563	0.3620***	0.0192
Inflation	−0.0017	0.0080	−0.0012	0.0080	0.0339	0.0271
FDI	0.1885**	0.0820	0.1364*	0.0813	0.1866***	0.0148
C	−75.4877***	5.9217	−76.1344***	6.2909	N/A	N/A

Note: ***, ** and * denotes 1%, 5% and 10% level of significance respectively.

The results from Table 5 suggest that income, employment and political regime are highly significant drivers of access to clean fuels and technology for cooking and they are robust across different estimations. From the results, it is observed that a 1% increase in income will lead to a 9.17–9.97% growth in access to clean fuels and technology while a percentage increase in employment and a unit increase in the political regime towards democracy contribute 0.29–0.34% and 0.26–0.36% increase in access to clean fuels and technology respectively. When FDI increases by 1% access to clean fuels and technology increases by 0.13–0.19%. Similarly, we find from the results in Table 6 that income, employment and political regime positively drive access to electricity and the results are robust across all estimations. A 1% increase in income is associated with a 0.84–1.46% increase in access to electricity while a 1% increase in employment increases access to electricity by 0.03–0.04%. A unit increase in the level of political regime towards democracy leads to a 0.08–0.09% growth in access to electricity. A 1% increase in FDI inflows increases access to electricity by 0.15–0.18% and an increase in the general price level also reduces access to electricity by 0.002%

Table 6. Regression results for access to electricity.

	Fixed effect		Random effect		FMOLS	
Variable	Coefficient	Std. Error	Coefficient	Std. Error	Coefficient	Std. Error
Income	1.1616***	0.2089	0.8466***	0.171210	1.4592***	0.0868
Employment	0.0306**	0.0139	0.0321***	0.011322	0.0436***	0.0065
Political regime	0.0901***	0.0157	0.0805***	0.014984	0.0832***	0.0061
Inflation	−0.0019	0.0022	−0.0021	0.002235	−0.0017*	0.0009
FDI	0.1626***	0.0227	0.1875***	0.021655	0.1533***	0.0087
C	1.0785	1.6436	2.7100*	1.453877	N/A	N/A

Note: *** and * denotes 1% and 10% level of significance respectively.

Table 7. Granger Causality analysis results for access to clean fuels and technology.

	Dependent Variable					
	Clean fuel	Income	Employment	Political regime	Inflation	FDI
Clean fuel		1.664	6.6300*	0.2747	5.8906**	0.4862
Income	63.845***		14.9184***	0.0450	4.4407**	0.4766
Employment	17.3635***	0.1825		2.2231	0.0254	0.1873
Political regime	2.7748*	0.0849	10.3333***		0.0436	0.1195
Inflation	0.0493	0.1090	0.0659	0.0365		0.6832
FDI	2.8106*	4.2420**	11.5191***	0.0935	0.4884	

Note: ***, ** and * denotes 1%, 5% and 10% level of significance respectively.

4.3. Causality test

Having confirmed the existence of a long run stable equilibrium among the variables, we performed the Toda-Yamamoto causality tests to determine the direction of causal relationships between variables, with results presented in Table 7. A bidirectional relationship is established between employment and access to clean fuels and technology. Furthermore, a unidirectional relationship from growth in income to access to clean fuels and technology, and to employment as well as to inflation is observed at 1% and 5% respectively while a unidirectional relationship is also observed from political regime type to access to clean fuels and technology and to employment at 10% and 1% levels of significance respectively. A unidirectional relationship runs from access to clean fuels and technology to inflation at 5% significance level. Finally, a unidirectional relationship is found to exist from FDI to access to clean fuels and technology, to income and to employment at the 10%, 5% and 1% levels of significance respectively.

The following illustrates the directions of causality:
Employment ←→ Clean energy accessibility
Inflation ←→ Clean energy accessibility
Political regime → Clean energy accessibility
Financial development → Clean energy accessibility

4.4. Discussion of findings

The results show that income is important for access to clean fuels and technology for cooking as well as for access to electricity. Growth in a country's GDP is expected to yield gains that trickle down to households in many forms including increased income. At the household level, income and wealth have been found to be a significant determinant of adoption of clean fuels and technology as well as adoption of electricity (Choumert-Nkolo et al., 2019; Rahut et al., 2017; Karimu et al., 2016; Malla and Timilsina, 2014). Particularly in the case of access to electricity, Bonan et al. (2017) argue that beyond household decisions to connect to grid electricity, accessing electricity requires an extensive network of infrastructure to exist. Kemmler (2007) also show that the degree of community electrification and the quality of electricity supply are more relevant in determining access to electricity than households' spending power. This indicates that especially in the case of access to electricity, household incomes alone may not be enough if supply side factors are constrained. Increase in economies' income (GDP growth) thus affords countries the means to provide the needed infrastructure and extend grid access to a larger proportion of the population who can then connect to their households subsequently. With regards to clean fuels and technology for cooking, studies have shown that some countries have embarked on various policy interventions including subsidizing cost of LPG (Calzada and Sanz, 2018; Andadari et al., 2014) and providing free LPG equipment (Adjei-Mantey and Takeuchi, 2019; Asante et al., 2018) to promote usage. Governments' ability to implement such policies is directly linked to their capacity to fund them and hence they would have the fiscal space to do these if the economy grows. Thus, increase in economic growth and consequently, income tends to play a positive role in enhancing access to clean fuels and this corroborates the findings of Cary (2019). Similarly, FDI was found to have a positive effect on access to electricity. FDI inflows help to set up the aforementioned capital-intensive infrastructure needed to extend electric power to different parts of the country and hence has the potential to improve access to electricity. This outcome is in line with the findings by D'Amelio et al. (2016) and Zhang et al. (2019).

Closely related to income and economic growth is the rate of employment. Economic growth often leads to economic expansion which opens up job opportunities thus reducing the unemployment rate. While it remains a possibility, that in cases where economic growth is not driven by growth in the real sector, the potential for such growth to reduce employment may be limited, our causality tests show that at least for the countries contained in our sample, GDP growth leads to growth in employment and confirms the hypothesis that, generally, economic growth is likely to trigger growth in employment. In both access to clean fuels and technology for cooking and access to electricity, a positive and significant relationship is seen and maintained across all models. Employment increases the incomes of households and enhances their ability to afford and thus households are likely to choose clean cooking fuels and technology. Such households are also able to have access to electricity. This confirms the results of Twumasi et al. (2020) who found that access to off-farm employment positively related to households' choice of clean cooking energy. Our study found a bidirectional causal relationship between employment and access to clean fuels and technology for cooking. This could result from the fact that as households increase their use of clean fuels due to increased spending power which results from growth in employment, the clean cooking fuel and technologies sector and allied sectors expand to meet the growth in demand. This translates into more job openings thus further reducing unemployment. For example, recent studies have shown the use of improved cookstoves as an important tool to policymakers in the bid to promote clean cooking technologies (Schilmann et al., 2019; Onakomaiya et al., 2019; van Gemert et al., 2019). The manufacture and distribution of such improved cookstoves on a large scale to support government intervention programs and to meet increased demand is likely to open up more job opportunities.

Political regime is also found to positively influence access to clean fuels. Generally, the more a political regime leans towards democracy, the higher the quality of institutions in that country. This is because as the regime gets more democratic, the more likely it is for state and regulatory institutions to operate independently without interference from the government coupled with better funding allocation as well as greater potential for accountability under such regimes. These tend to increase their efficiency and quality. The nature of the political regime thus, often moves together with institutional quality. The positive relationship between political regime and access to clean fuels corroborates the findings of studies such as Cary (2019) and Uzar (2020) who found that access to clean fuels and consumption of renewable energy respectively increases with an enabling political regime and institutional quality. Recent literature such as Sun et al. (2019) and Shah et al. (2020) found that institutional quality is responsible for enhancing energy efficiency and reducing environmental degradation respectively. Our findings also confirm the findings of Amuakwa-Mensah and Adom (2017) and Adams et al. (2016) which found that political regime in favour of democracy tends to reduce environmental degradation. While these studies did not measure access to clean energy directly, the role of the political regime in enhancing access to clean energy can be inferred. Energy efficiency implies less energy per unit of output. An increase in energy efficiency therefore means more energy is available for use by other groups of the population which could contribute to increasing access to energy other things being equal. Also, a reduction in environmental degradation implies the promotion of environmentally friendly forms of energy hence an increase in access to clean fuels. The significant role of the political regime in access to energy is confirmed by Kwakwa (2019) and Sarkodie and Adams (2018); the latter noting that political institutional quality is crucial in the economic and social readiness to mitigate the impact of climate change and that promoting access to clean fuel could be just one of the ways institutions reduce climate change impacts. The aforementioned studies argue that strong institutions, often found in more democratic political regimes, are able to enforce regulations regarding the environment and thus lead to promoting the accessibility and usage of clean fuels. Azam et al. (2020), however, found the political regime and institutional quality to increase energy consumption based on oil and fossil resources thereby increasing emissions. This could be so because they explained that in the countries they studied there might be more civil freedom and with a political system that has little concern for environmental issues. Our result from the causality tests found the political regime to cause employment. Democracies are characterized by the freedom and motivation to invest and to make economic profits. This affords investors and businesses the opportunities to operate without intimidation and given a fair business environment, the economy expands, leading to more job opportunities. Price (inflation) found to reduce access to electricity is in line with economic theory and previous studies. The inflationary rate in the sub-region is comparatively high making it difficult for many to access electricity. Thus, the higher price increases the opportunity cost of clean energy which reduces the quantity of clean energy that is bought and consumed. Adom and Kwakwa (2019) found that electricity price reduces electricity consumption in Ghana.

In summary, we argue that pursuing increased incomes and economic growth in SSA is important in enhancing access to clean cooking fuels and technology and access to electricity. We further argue that growth policies should not neglect to focus on the real sectors of the economy since these sectors have the capacity to open up jobs for more persons when they expand. This way, increased employment will accompany economic growth and with it, a consequent increase in access to clean energy. Furthermore, political regimes that lean towards democracies can increase the effectiveness of institutions to perform regulatory roles without fear of the ruling class and by their effectiveness, help prevent the gains from growth from leaking away through corruption or underground activities. This is crucial to enhancing access to clean energy. As these become the focus, SDG 7 stands a strong chance of being achieved even by developing and less developed countries.

5. Conclusions

Goal 7 of the SDGs requires that sustainable and modern energy which are both affordable and reliable be made accessible for all. In order to contribute to the achievement of this goal, this study examined the drivers of clean energy accessibility in sub-Saharan Africa to provide an empirical basis to motivate policy decisions using macro level data on a panel of 31 Sub-Sahara African countries. Two variables that measure access to clean energy were considered—access to clean fuels and technology for cooking and access to electricity. By employing standard panel cointegration and causality techniques, we find that in the long run, GDP growth, employment growth, political regime, inflation and FDI jointly determine access to clean energy.

We find that increased income and subsequently economic growth is crucial for enhancing growth in access to clean fuels as it expands the economy and gives governments the fiscal ability to extend electricity infrastructure and also to provide clean cooking fuels and technology interventions to residents. At the micro level, economic growth is expected to yield gains that trickle down to households in the form of increased household incomes allowing them to demand more clean energy. In addition, growth policies should focus on the real sectors of the economy which have the potential to create more job opportunities when those sectors are growing to boost employment. Crucial to this analysis is the fact that more democratic political regimes are important if the gains from economic growth will be translated into increased growth in access to clean energy as strong institutions often thrive in such political regimes. Economies with weak institutions are unable to guard the gains of growth probably due to their inability to minimize corruption and/or the stifling of their operations which may be the case under less democratic regimes and such growth may not have a lasting trickling-down effect on households for them to be able to have more access to clean energy. We therefore recommend that sub-Sahara African governments and indeed governments of developing countries take steps to strengthen the political regime and allow state and regulatory institutions the necessary autonomy to operate as often happens in democracies, without interference. This political environment gives investors and businesses confidence in the economy which encourages investment with the potential to generate more job openings and increase employment as a consequence. This will also ensure that as economic growth is pursued, its positive impact on access to clean energy will be realized. Maintaining not just low prices but stable prices in the sub region should be of concern authorities to promote higher access to clean energy.

Conflicts of interest

The authors declare no conflict of interest.

References

Adams S, Adom PK, Klobodu EKM (2016) Urbanization, regime type and durability, and environmental degradation in Ghana. *Environ Sci Pollution Res* 23: 23825–23839.

Adom PK, Bekoe W, Akoena SKK (2012) Modelling aggregate domestic electricity demand in Ghana: An autoregressive distributed lag bounds cointegration approach. *Energy policy* 42: 530–537.

Adom PK, Bekoe W (2013) Modelling electricity demand in Ghana revisited: The role of policy regime changes. *Energy policy* 61: 42–50.

Adom PK (2015) Determinants of energy intensity in South Africa: testing for structural effects in parameters. *Energy* 89: 334–346.

Adom PK, Kwakwa PA (2019) Does Technological Progress Provide a Win-Win Situation in Energy Consumption? The Case of Ghana, In: *Energy and Environmental Strategies in the Era of Globalization*, Springer, Cham, 363–385.

Adjei-Mantey K, Takeuchi K (2019) Does free distribution of equipment work? Measuring the impacts of Ghana's Rural LPG Promotion Program. Paper presented at the 2019 annual meeting of the Society for Environmental Economics and Policy Studies. September 2019, Japan.

Al-Bajjali SK, Shamayleh AY (2018) Estimating the determinants of electricity consumption in Jordan. *Energy* 147: 1311–1320.

Amuakwa-Mensah F, Adom PK (2017) Quality of institution and the FEG (forest, energy intensity, and globalization)—environment relationships in sub-Saharan Africa. *Environ Sci Pollut Res* 24: 17455–17473.

Andadari RK, Mulder P, Rietveld P (2014) Energy poverty reduction by fuel switching. Impact evaluation of the LPG conversion program in Indonesia. *Energy Policy* 66: 436–449.

Asante KP, Afari-Asiedu S, Abdulai MA, et al. (2018) Ghana's rural liquefied petroleum gas program scale up: A case study. *Energy Sustainable Dev* 46: 94–102.

Asumadu-Sarkodie S, Yadav P (2019) Achieving a cleaner environment via the environmental Kuznets curve hypothesis: determinants of electricity access and pollution in India. *Clean Technol Environ Policy* 21: 1883–1889.

Azam M, Liu L, Ahmad N (2020) Impact of institutional quality on environment and energy consumption: evidence from developing world. *Environ Dev Sustainability* 23: 1646–1667.

Bonan J, Pareglio S, Tavoni M (2017) Access to modern energy: a review of barriers, drivers and impacts. *Environ Dev Econ* 22: 491–516.

Calzada J, Sanz A (2018) Universal access to clean cookstoves: Evaluation of a public program in Peru. *Energy Policy* 118: 559–572.

Cary M (2019) Increasing access to clean fuels and clean technologies: a club convergence approach. *Clean Technol* 1: 247–264.

Choumert-Nkolo J, Combes Motel P, Le Roux L (2019) Stacking up the ladder: a panel data analysis of Tanzanian household energy choices. *World Dev* 115: 222–235.

Churchill SA, Ivanovski K, Munyanyi ME (2021) Income inequality and renewable energy consumption: Time-varying non-parametric evidence. *J Clean Prod* 296: 126306.

D'Amelio M, Garrone P, Piscitello L (2016) Can multinational enterprises light up developing countries?: Evidences from the access to electricity in sub-Saharan Africa. *World Dev* 88: 12–32.

Das S, De Groote H, Behera B (2014) Determinants of household energy use in Bhutan. *Energy* 69: 661–672.

Ergun SJ, Owusu PA, Rivas MF (2019) Determinants of renewable energy consumption in Africa. *Environ Sci Pollut Res* 26: 15390–15405.

Ekpo UN, Chuku CA, Effiong EL (2011) The dynamics of electricity demand and consumption in Nigeria: application of the bounds testing approach. *Current Res J Econ Theory* 3: 43–52.

Hassan ST, Khan SUD, Xia E, et al. (2020) Role of institutions in correcting environmental pollution: An empirical investigation. *Sustainable Cities Society* 53: 101901.

Ghouali YZ, Belmokaddem M, Sahraoui MA, et al. (2015) Factors affecting CO_2 emissions in the BRICS countries: a panel data analysis. *Pro Econ Financ* 26: 114–125.

Ibrahim MH, Law SH (2016) Institutional Quality and CO_2 Emission–Trade Relations: Evidence from S ub-S aharan A frica. *South Afri J Econ* 84: 323–340.

Im KS, Pesaran H, Shin Y (2003) Testing for unit roots in heterogeneous panels. *J Econometrics* 115: 53–74.

Inglesi-Lotz R, Pouris A (2016) On the causality and determinants of energy and electricity demand in South Africa: A review. *Energy Sour* 11: 626–636.

International Energy Agency (2019) Global Energy and CO_2 Status Report 2018. Available from: https://www.eenews.net/assets/2019/03/26/document_cw_01.pdf.

IEA (2020a) SDG7: Data and Projections. Available from: https://www.iea.org/reports/sdg7-data-and-projections/modern-renewables.

IEA (2020b) Global Energy Review 2020: The impacts of the Covid-19 crisis on global energy demand and CO_2 emissions. Available from: https://www.iea.org/reports/global-energy-review-2020/renewables.

Karimu A, Mensah JT, Adu G (2016) Who adopts LPG as main cooking fuel and why? Empirical evidence on Ghana based on national survey. *World Dev* 85: 43–57.

Keho Y (2016) What drives energy consumption in developing countries? The experience of selected African countries. *Energy Policy* 91: 233–246.

Kemmler A (2007) Factors influencing household access to electricity in India. *Energy Sustainable Dev* 11: 13–20.

Louw K, Conradie B, Howells M, et al. (2008) Determinants of electricity demand for newly electrified low-income African households. *Energy policy* 36: 2812–2818.

Kinda T (2010) Investment climate and FDI in developing countries: firm-level evidence. *World Dev* 38: 498–513.

Kwakwa PA (2017) Electricity consumption in Egypt: a long-run analysis of its determinants. *OPEC Energy Rev* 41: 3–22.

Kwakwa PA (2018a) An analysis of the determinants of electricity consumption in Benin. *J Energy Manage Technol* 2: 42–59.

Kwakwa PA, Wiafe ED, Alhassan H (2013) Households Energy Choice in Ghana. *J Empirical Econ* 1: 96–103.

Kwakwa PA, Adu G, Osei-Fosu AK (2018) A time series analysis of fossil fuel consumption in Sub-Saharan Africa: evidence from Ghana, Kenya and South Africa. *Int J Sustainable Energy Plann Manage* 17: 31–44.

Kwakwa PA (2018b) On the determinants *of* electricity power losses*:* empirics from Ghana. *OPEC Energy Rev* 42: 3–21.

Kwakwa PA (2019) Towards sustainable energy: what have natural resource extraction, political regime and urbanization got to do with it? *J Energy Manage Technol* 3: 44–57.

Kwakwa PA (2020) What determines renewable energy consumption? Startling evidence from Ghana. *Int J Energy Sector Manage* 15: 101–118.

Kwakwa PA (2021) The carbon dioxide emissions effect of income growth, electricity consumption and electricity power crisis. *Manage Environ Quality* 32: 470–487.

Kwakwa PA, Adusah-Poku F (2019) Determinants of electricity consumption and energy intensity in South Africa. *Green Financ* 1: 387–404.

Lu WM, Kweh QL, Nourani M, et al. (2021) Political Governance, Corruption Perceptions Index, and National Dynamic Energy Efficiency. *J Clean Prod* 295: 126505.

Maddala GS, Wu S (1999) A comparative study of unit root tests with panel data and a new simple test. *Oxford Bull Econ Stat* 61: 631–652.

Malla S, Timilsina GR (2014) Household cooking fuel choice and adoption of improved cookstoves in developing countries: A review. World Bank Policy Research Working Paper 6903. Muller and Yan, 2018.

Matei I (2017) Is there a Link between Renewable Energy Consumption and Economic Growth? A Dynamic Panel Investigation for the OECD Countries. *Revue d'economie politique* 127: 985–1012.

Mensah JT, Adu G (2015) An empirical analysis of household energy choice in Ghana. *Renew Sust Energ Rev* 51: 1402–1411.

Moktadir MA, Ali SM, Jabbour CJC, et al. (2019) Key factors for energy-efficient supply chains: Implications for energy policy in emerging economies. *Energy* 189: 116129.

Onakomaiya D, Gyamfi J, Iwelunmor J, et al. (2019) Implementation of clean cookstove interventions and its effects on blood pressure in low-income and middle-income countries: systematic review. *BMJ Open* 9: e026517.

Ogwumike FO, Ozughalu UM, Abiona GA (2014) Household energy use and determinants: Evidence from Nigeria. *Int J Energy Econ Policy* 4: 248.

Özcan KM, Gülay E, Üçdoğruk Ş (2013) Economic and demographic determinants of household energy use in Turkey. *Energy Policy* 60: 550–557.

Paudel U, Khatri U, Pant KP (2018) Understanding the determinants of household cooking fuel choice in Afghanistan: a multinomial logit estimation. *Energy* 156: 55–62.

Poloamina ID, Umoh UC (2013) The determinants of electricity access in Sub-Saharan Africa. *Empirical Econometrics Quant Econ Lett* 2: 65–74.

Polity IV Project (2020) Available from: https://www.systemicpeace.org/inscrdata.html.

Rahut DB, Behera B, Ali A, et al. (2017) A ladder within a ladder: understanding the factors influencing a household's domestic use of electricity in four African countries. *Energy Econ* 66: 167–181.

Sarkodie SA, Adams S (2018) Renewable energy, nuclear energy, and environmental pollution: Accounting for political institutional quality in South Africa. *Sci Total Environ* 643: 1590–1601.

Schilmann A, Riojas-Rodriguez H, Catalan-Vasquez M, et al. (2019) A follow-up study after an improved cookstove intervention in rural Mexico: Estimation of household energy use and chronic PM2.5 exposure. *Environ Int* 131: 105013.

Shah SZ, Chughtai S, Simonetti B (2020) Renewable energy, institutional stability, environment and economic growth nexus of D-8 countries. *Energy Strat Rev* 29: 100484.

Simionescu M, Strielkowski W, Tvaronavičienė M (2020) Renewable energy in final energy consumption and income in the EU-28 countries. *Energies* 13: 2280.

Sun H, Edziah BK, Sun C, et al. (2019) Institutional quality, green innovation and energy efficiency. *Energy Policy* 135: 111002.

Twerefou DK, Bekoe W, Adusah-Poku F (2016) An empirical examination of the Environmental Kuznets Curve hypothesis for carbon dioxide emissions in Ghana: an ARDL approach. *Environ Socio-Econ Stud* 4: 1–12.

Twumasi MA, Jiang Y, Ameyaw B, et al. (2020) The impact of credit accessibility on rural households clean cooking energy consumption: The case of Ghana. *Energy Reports* 6: 974–983.

Uzar U (2020) Political economy of renewable energy: Does institutional quality make a difference in renewable energy consumption? *Renewable Energy* 155: 591–603.

van Gemert F, de Jong C, Kirenga B, et al. (2019) Effects and acceptability of implementing improved cookstoves and heaters to reduce household air pollution: a FRESH AIR study. *NPJ Primary Care Resp Med* 29: 1–9.

Wang Y, Chen L, Kubota J (2016) The relationship between urbanization, energy use and carbon emissions: evidence from a panel of Association of South East Asian Nations (ASEAN) countries. *J Clean Prod* 112: 1368–1374.

World Bank (2020) World Development Indicators. Available from: https://databank.worldbank.org/reports.aspx?source=world-development-indicators.

Zhang T, Shi X, Zhang D, et al. (2019) Socio-economic development and electricity access in developing economies: A long-run model averaging approach. *Energy Policy* 132: 223–231.

Ziramba E (2008) The demand for residential electricity in South Africa. *Energy policy* 36: 3460–3466.