

# DYNAMIC NEXUS BETWEEN ENERGY ACCESSIBILITY AND ENERGY POVERTY FOR COUNTRIES IN EASTERN AFRICA

Cornelius Kiprono Serem<sup>1\*</sup>, Richard Siele<sup>2</sup>, Muiyiwa Samuel Adamarola<sup>3</sup>

Department of Economics, Moi University, Kenya.

**\*Corresponding Author**  
**Cornelius Kiprono Serem**

Department of Economics,  
Moi University, Kenya.

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**Abstract:** Energy access is crucial for the advancement of society, the economy, and politics. East Africa yet faces significant energy shortages while having huge potential for both fossil and renewable energy sources. The resources of the continent are underutilized, exported in raw form, or lost during extraction or transport. As a result, the local population has limited access to supplies, and biomass is mostly used for energy use. The countries in Eastern Africa have different levels of access to clean energy. In general, some nations have significantly improved access to electricity, while others continue to face difficulties. For some reasons, East Africa needs a comprehensive and multi-faceted approach. This approach should take into account the unique challenges and opportunities of the region. Thus, it's critical to promote infrastructure investments for renewable energy sources including solar, wind, geothermal, and hydropower. Infrastructure for renewable energy can be built and expanded with the help of governments and private investors. Government should consider collaboration with the private sector companies, and non-governmental organizations (NGOs) to leverage resources and expertise to accelerate the adoption of clean energy technologies and improve energy accessibility in the region.

**Keywords:** Clean Energy, Energy Poverty, East Africa.

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## 1. Introduction to the study

Over the past 30 years, a growing body of "energy for development" literature has focused on the availability of energy services and the crucial role they play in reducing poverty and promoting socioeconomic development (Mulugetta et al., 2022 and Gaye, 2007). Global policy conversations have been affected by the need to increase access to cutting-edge energy services. In 2012, the Energy Access Year was declared, and by 2030, all people will have access to modern energy services. Additionally, it should be underlined that "energy access" is becoming a focus of national-level public policy and is no longer merely a concern of donor organizations and international organizations. Whether or whether these debates can be incorporated into sectoral policy choices that enable the actual execution of expanding access to new energy sources remains unclear. One possible reason for this is that the old method of development planning does not mesh well with the fact that energy affects so many different areas. Not because they don't see energy as a key development issue, but because the 'energy access' issue hasn't been presented in a way that resonates with national development goals, countries have yet to 'own' the agenda around energy.

Despite this enormous potential, the region's energy industry is still largely underdeveloped. It is distinguished by extremely low levels

of modern energy access, low per-person consumption, and a heavy reliance on biomass energy, which makes up more than 90% of the region's total energy consumption. Less than 1% of the region's rural areas have access to electricity. The traditional sector's energy needs are met by wood fuel, including those of rural and low-income urban residences and some cottage businesses; while a sizable share of the country's commercial energy needs are satisfied by electricity and petroleum products. Petroleum and electricity, which power the contemporary economy, dominate the energy industry. Most of biomass usage occurs at the domestic level (GTZ, 2007). The commercial, industrial, and service sectors all make extensive use of biomass. The recent increasing use of biomass in these industries has been blamed on rising petroleum product prices, insufficient and ineffective power supply systems brought on by stunted capacity growth, and underdeveloped distribution and transmission facilities.

Energy's significance in the modern economy cannot be disputed, even if it is not considered an input in the conventional growth models. For instance, Hall and Klitgaard (2012) focused on the contribution of energy to economic growth and the cap on future growth as a result of our reliance on fossil fuels. This explains the industrial revolution as a releasing of the constraints on economic growth due to the development of methods of using coal and the discovery of new fossil fuel resources. Also, it was found that the

elasticity of substitution between a capital-labour aggregate and energy is less than unity, which implies that when energy services are scarce, they strongly constrain output growth resulting in a low income steady-state. When energy services are abundant the economy exhibits the behaviour of the 'modern growth regime' with the Solow model as a limiting case (Stern & Kander, 2012).

### 1.1 Access to Modern Energy

The percentage of individuals adopting clean energy for cooking has shown a notable increase over the years, rising from 50% in 2010 to 66% in 2019, as reported by the United Nations (Küfeoğlu, S. (2022). Renewable and non-renewable energy sources are derived from the environment. Some examples of energy sources include coal, natural gas, petroleum, hydropower, solar, and wind. The global demand for energy sources, such as fossil fuels and renewables, is significant. Despite significant advancements in expanding access to power and increasing the utilization of renewable energy in the electrical sector, as well as improvements in energy efficiency over the past decade, it is evident that the world is still a long way from achieving affordable, reliable, sustainable, and modern energy for everyone. The global power access rate experienced a significant improvement from 83% in 2010 to 90% in 2019, with an average yearly electrification rate of 0.876 percentage points. The global access deficit has decreased from 1.22 billion in 2010 to 759 million in 2019.

According to the United Nations (2021b), despite significant efforts, it is projected that approximately 660 million people will still lack access to electricity by 2030. Bioenergy is identified as the most prevalent form of renewable energy. According to the United Nations (2021a), around three billion individuals rely on energy sources like wood, coal, and animal waste. Even though it is not regarded as an input in the traditional growth models, energy's importance in the contemporary economy cannot be denied. For instance, Hall and Klitgaard (2012) concentrated on how energy affects economic growth and how our reliance on fossil fuels limits future growth. According to this, the development of coal-using techniques and the discovery of new fossil fuel supplies caused economic growth to be freed from its restraints, which is how the industrial revolution is explained.

### 1.2 Relationship between Energy Access and Energy Poverty

Batinge, Musango, & Brent (2019) examined different scenarios to ascertain roadmaps for universal energy access in unmet African electricity market. This was accomplished by employing system dynamics to create the Africa Electricity Access (AFELA) model. Electricity Access, Electricity Capital Investment, and Electricity Supply Capacity are the three sub-models that make up AFELA. To find the quickest path toward achieving widespread access to electricity in Africa, four scenarios were explored. The four scenarios were the baseline, economies of scale, capacity utilization factor, and investment in electricity access. The findings demonstrate that the most feasible path to achieving universal access to electricity is the Electricity access investment scenario, which calls for an increase in the annual power investment of 2% of GDP. Given the limited resources available from multilateral and bilateral aid as well as the national governments' budgetary restrictions, private sector investment is essential. Thus, the report recommends private sector financing as a means of addressing the

financial issue and accelerating the achievement of universal access to power.

Sambodo and Novandra (2019) divided energy poverty into three categories: no access to power, spending more than 10% of total spending, and use of less than 32.4 kWh per home per month. For the study, household and neighborhood questionnaires were evaluated. Three significant findings came from the inquiry. First, the percentage of homes in the range of energy poverty based on expenditure criterion was around 53%, while the percentage based on electricity usage was about 22%. Compared to energy-poor households, non-energy-poor households spend more on both food (16.2%) and non-food (24.3%). Finally, the village's malnutrition rate declined as a result of availability to power and contemporary cooking fuel.

Drago & Gatto, A. (2023) used interval-based composite indicators and triplex representations of intervals to measure and assess access to electricity in 54 developing countries as a concept approximating relevant aspects of energy poverty. Because it accurately measures how much electricity is available to individuals and how robust and vulnerable people in underdeveloped nations are when they lose access to energy, the proposed composite meter is novel. The study concluded that one group of emerging countries is more susceptible to domestic and global events than the other after analyzing the various representations. Other nations, however, are more resistant to issues with access to electricity. War and conflict can affect the index used to gauge energy poverty. However, the index indicates that these elements contribute to subpar performance.

## 2. Research Methodology

**Data source:** the data used was sourced from World Bank database for the period 2000-2020. **Measurement of Variables:** The dependent variable is energy poverty. It was measured as a percentage of population without access to energy. The independent variable access to clean fuels and technologies and was measured using percentage of households accessing clean fuels and technologies to total population. Other variables include energy access to rural and urban centers and were measured using the percentage to the total population. Population growth and GDP per capita were control variables.

**Econometric Model:** the model of interest was fixed effects model. A fixed effects model makes the assumption that the relevant parameters are constant and unique across the entities (i.e. Eastern African countries). A fixed-effects model is a statistical approach used in econometrics and other fields to control for unobserved heterogeneity or individual-specific effects that may be present in panel data or longitudinal datasets. It is commonly employed when analyzing data with multiple individuals, entities, or groups observed over time.

Individual-specific effects are viewed in a fixed-effects model as fixed constants that are unique to each entity or group and do not change over time. The model implies that these effects are related to but unaffected by the explanatory factors. The model can take into account the timeinvariant variations among entities by integrating individual-specific fixed effects, enabling a more precise estimation of the correlations between the dependent variable and the independent variables.

The general form of a fixed-effects model can be expressed as:

$$Y_{it} = \beta * X_{it} + \mu_i + \varepsilon_{it}$$

Where:  $Y_{it}$  represents the dependent variable (energy poverty) for entity  $i$  at time  $t$ .  $X_{it}$  is a vector of explanatory variables (access to fuels and technologies, access to both rural and urban populations) for entity  $i$  at time  $t$ .  $\beta$  represents the coefficients associated with the explanatory variables.  $\mu_i$  denotes the fixed effect for entity  $i$  (time-invariant characteristics).  $\varepsilon_{it}$  is the error term representing the unobservable factors and random errors.

The regression is then run on the differenced data, and the coefficients can be interpreted as the relationship between the changes in the variables. Fixed-effects models are particularly useful when dealing with unobserved heterogeneity and time-invariant characteristics, making them suitable for studying individual-level or entity-level effects while controlling for confounding factors that do not change over time.

### 3. Results and Discussions

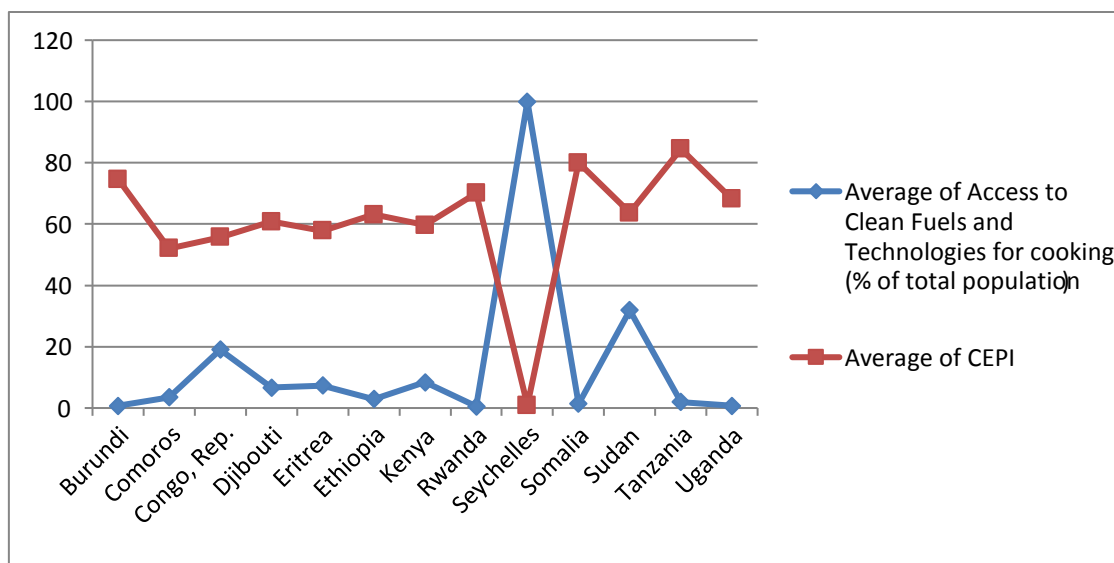
Table 1 presents descriptive for each variable studied. Some of the central measures of tendency provided include the mean, standard deviation, minimum and maximum values. The reason behind this is because the mean is unbiased, more efficient, sufficient and consistent estimator.

**Table 1: Summary Statistics**

| Main Variables           | Mean    | Std. Dev. | Min    | Max       |
|--------------------------|---------|-----------|--------|-----------|
| Energy Poverty           | 62.118  | 25.678    | 0      | 98.107    |
| Clean fuel               | 14.609  | 27.100    | .1     | 100       |
| E. access rural pop      | 27.484  | 27.018    | .537   | 100       |
| E. access urban pop      | 66.548  | 18.659    | 20.311 | 100       |
| <b>Control Variables</b> |         |           |        |           |
| Pop growth               | 2.526   | .882      | -2.629 | 5.078     |
| GDP per capita           | 2167.65 | 3563.704  | 255.1  | 16992.033 |

The standard deviation is an essential statistical measure that quantifies the variability or dispersion of a dataset. Its importance can be understood in the following ways: Measuring variability: Standard deviation provides a measure of how spread out the values in a dataset is from the mean. It allows us to understand the extent to which data points deviate from the average. A higher standard deviation indicates greater variability, while a lower standard deviation indicates less variability.

Controlling the population growth rate and GDP per capita, Eastern Africa has a high average rate of energy poverty. This provides information on the distribution and variations of energy poverty in the region. A sizable fraction of the population in Eastern Africa does not have access to basic energy services. Energy poverty is a condition where people or households lack reliable, cheap access to modern energy sources for needs like heating, lighting, and cooking. The standard deviation of 25.68 implies there are large regional differences in energy poverty in Eastern Africa. This demonstrates how the prevalence of energy poverty varies greatly throughout the countries or areas of Eastern Africa.



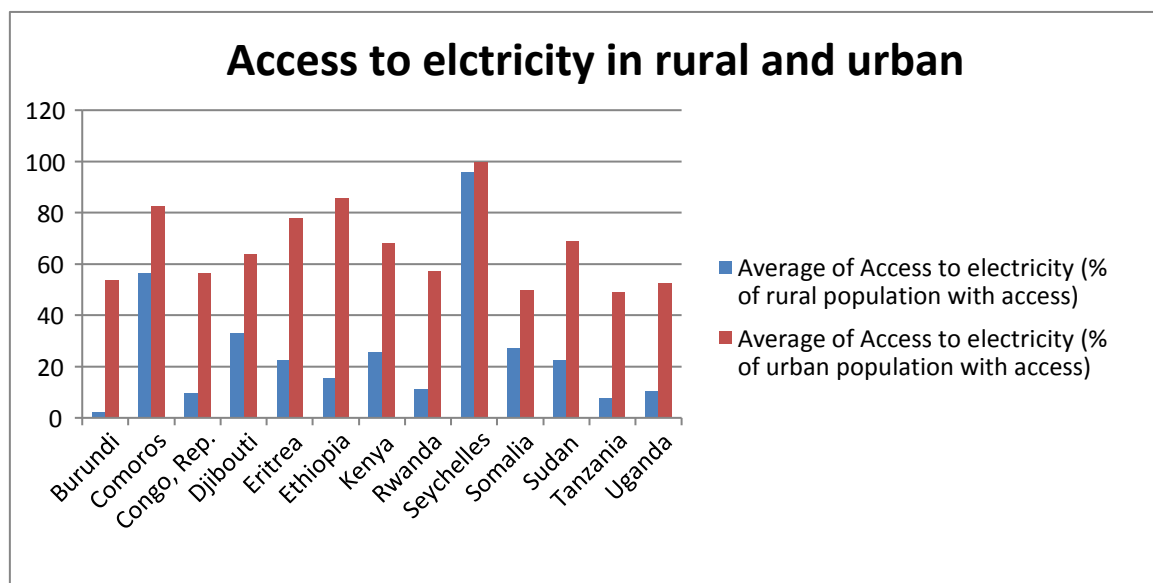
**Figure 1: Access to Clean Energy and Energy Poverty (CEPI)**

The spread of energy poverty rates is greater when the standard deviation is higher, indicating a wider discrepancy in access to energy services. The substantial standard deviation suggests that when developing interventions and programs, policymakers and development professionals should take the variation in energy poverty rates into account. It implies that addressing the unique energy needs and problems in various regions may require personalized methods rather than a one-size-fits-all approach.

Figure 1 present access to electricity as percentage to clean fuels and technologies and energy poverty index of eastern Africa countries. It provides a general overview of the electricity access situation in Eastern Africa based on data collected. The countries in Eastern Africa have different levels of access to clean energy. In general, some nations have significantly improved access to electricity, while others continue to face difficulties. Here are some crucial details: Kenya: The region's efforts to electrify have been spearheaded by Kenya.

By 2021, the nation had made significant strides toward expanding electricity access, with the majority of its citizens having access to grid-connected or off-grid electricity. Tanzania has made significant progress in increasing access to electricity. Uganda has improved the availability

of electricity, especially in urban areas. However, a sizable portion of the rural population still does not have access to electricity, making rural electrification a challenge (see Figure 2).



**Figure 2: Average Energy Access to Rural and Urban Population**

In Rwanda, the country has improved access to electricity significantly over time. The government has put forward cutting-edge strategies, such as off-grid options, to increase access to electricity, particularly in rural areas. Ethiopia has been working to increase the number of people who have access to electricity, primarily through sizable hydropower projects. Despite these achievement in improving electricity access, rural areas of most of East African nations, still lacked access to electricity as of 2021. EA Countries with improved access in rural areas include Comoros, Djibouti, Kenya Seychelles Somali and Sudan. Other nations: Other Eastern African nations like Burundi, have encountered significant difficulties in achieving widespread access to electricity. Progress in these nations has been hampered by inadequate infrastructure, unstable political environments, and financial constraints.

Results provided in Table 2 are from fixed effect regression. A fixed effects model makes the assumption that the relevant parameters are constant and unique across the entities (i.e. Eastern African countries). The EA countries are the only ones thought to be relevant in this model, and the conclusions are applied to just these particular countries.

**Table 2: Panel Fixed Effect Regression Results**

| Energy Poverty      | Coef. | St.Err.  | t                    | p    | [95% Conf | Interval] Sig |
|---------------------|-------|----------|----------------------|------|-----------|---------------|
| Clean fuel and tech | -.057 | .018     | -3.19                | .002 | -.093     | -.022***      |
| Access rural pop    | -.788 | .016     | -48.44               | .000 | -.820     | -.756***      |
| Access urban pop    | -.263 | .015     | -17.06               | .000 | -.293     | -.232***      |
| Pop growth          | .366  | .157     | 2.33                 | .021 | .056      | .676**        |
| GDP per capita      | .000  | .000     | 2.57                 | .011 | .000      | .001**        |
| Constant            | 98.72 | .948     | 104.15               | .000 | 96.85     | 100.589***    |
| Mean dependent var  |       | 60.383   | SD dependent var     |      |           | 25.496        |
| R-squared           |       | 0.987    | Number of obs        |      |           | 210           |
| F-test              |       | 2816.998 | Prob > F             |      |           | 0.000         |
| Akaike crit. (AIC)  |       | 682.624  | Bayesian crit. (BIC) |      |           | 702.707       |

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$

Fixed model treats each country as a separate parameter, and the analysis concentrates on the variation between these countries. Results indicate access to clean fuels and technologies have a negative and significant effect on eradication of energy poverty. Further, energy access to rural and urban populations has a huge impact in reducing energy poverty (negative and significant coefficients). According to Baltagi (2008), Wooldridge J. M. (2009) and Wooldridge, J. M. (2010), a fixed effects model has the

following advantages: Fixed effects models explicitly estimate the effects of various levels or categories (countries), allowing for causal inference. This is especially helpful when the researcher want to pinpoint the precise effects of various factors.

#### 4. Conclusion and Recommendations

The significant contribution of access to clean fuels and technologies means clean energy is critical and a significant

determinant of lowering energy poverty. In conclusion, When households lack access to clean, affordable energy and are in a bad financial or economic state, they are forced into energy poverty. Improved air quality, human health, and wellbeing, especially for women, are a few benefits of having access to clean energy sources for your home. The use of clean energy is essential for raising everyone's standard of living. Failure to reduce or eradicate energy poverty, East Africa will find it difficult to meet the SDG's goals of having energy access to all people. It is therefore recommended that to eradicate energy poverty and improve access to clean energy in East Africa, a comprehensive and multi-faceted approach is required. This approach should take into account the unique challenges and opportunities of the region. Here are some strategies that can be employed:

- i. It's critical to promote infrastructure investments for renewable energy sources including solar, wind, geothermal, and hydropower. Infrastructure for renewable energy can be built and expanded with the help of governments and private investors.
- ii. Promote energy efficiency measures to reduce overall energy demand. This can be achieved through awareness campaigns, incentives for energy-efficient appliances, and building codes that promote green building practices.
- iii. Since many areas in East Africa are remote and lack access to centralized power grids, offgrid solutions like decentralized solar systems, micro-grids, and mini-hydro power plants can play a significant role in providing clean energy to communities.
- iv. Governments should create a conducive policy and regulatory environment that promotes investment in clean energy. This includes providing incentives, subsidies, and tax breaks for clean energy projects, and streamlining the approval process for renewable energy initiatives.
- v. Public-Private Partnerships (PPPs): Collaboration between governments, private sector companies, and non-governmental organizations (NGOs) can leverage resources and expertise to accelerate the adoption of clean energy technologies.

## References

1. Baltagi, B. H. (2008). Forecasting with panel data. *Journal of forecasting*, 27(2), 153-173.
2. Drago, C., & Gatto, A. (2023). Gauging energy poverty in developing countries with a composite metric of electricity access. *Utilities Policy*, 81, 101486.
3. Gaye, A. (2007). Access to energy and human development. *Human development report, 2008*, 2007.
4. GTZ (2007): Eastern Africa Resource Base: GTZ Online Regional Energy Resource Base: Regional and Country Specific Energy Resource Database: II - Energy Resource.
5. Hall, C. A., Klitgaard, K. A., Hall, C. A., & Klitgaard, K. A. (2012). Explaining Economics from an Energy Perspective. *Energy and the Wealth of Nations: Understanding the Biophysical Economy*, 95-130.
6. Küfeoğlu, S. (2022). SDG-7 Affordable and Clean Energy. In *Emerging Technologies: Value Creation for Sustainable Development* (pp. 305-330). Cham: Springer International Publishing.
7. Mulugetta, Y., Sokona, Y., Trotter, P. A., Fankhauser, S., Omukuti, J., Somavilla Croxatto, L., ... & Yussuff, A. (2022). Africa needs context-relevant evidence to shape its clean energy future. *Nature Energy*, 7(11), 1015-1022.
8. Sambodo, M. T., & Novandra, R. (2019). The state of energy poverty in Indonesia and its impact on welfare. *Energy Policy*, 132, 113-121.
9. Stern, D. I., & Kander, A. (2012). The role of energy in the industrial revolution and modern economic growth. *The Energy Journal*, 33(3).
10. United Nations, The Sustainable Development Goals Report: 2021 [WWW Document]. U. N.
11. (2021b), <https://unstats.un.org/sdgs/report/2021/goal-13/>. Accessed 31 July 2021
12. Wooldridge, J. M. (2009). On estimating firm-level production functions using proxy variables to control for unobservables. *Economics letters*, 104(3), 112-114.
13. Wooldridge, J. M. (2010). *Econometric analysis of cross section and panel data*. MIT press.