**Explanation Electricity Access effect on Happiness: Empirical Evidence from African Great Lakes Countries (2012-2021)**

# Abstract

This study examines the relationship between electricity access and happiness in African Great Lakes Countries (GLCs using panel data from 2012 to 2021. Employing the Cantril ladder score as a measure of subjective well-being, the analysis investigates how electrification influences happiness, with a focus on rural-urban disparities. The baseline estimates, derived using Driscoll & Kraay standard errors, reveal a statistically significant and positive relationship between electricity access and happiness, particularly in rural areas, where the effect is substantially larger than in urban settings. To address endogeneity concerns, the study further employs an Instrumental Variable Two-Stage Least Squares (IV-2SLS) approach, which corroborates and amplifies these findings, underscoring the causal impact of electrification on well-being. Control variables, including education, financial development, health, and industrialization, consistently exhibit theoretically aligned and statistically significant effects, reinforcing the robustness of the model. The results highlight the transformative potential of electrification in enhancing happiness, suggesting that policies targeting underserved regions could yield disproportionate well-being gains. This study provides region-specific insights often obscured in global analyses, thereby contributing to the broader discourse on energy access and development.

**Keywords:** amplifies,electricity, happiness, Great Lakes Countries , Two-Stage Least Squares

**JEL Classifications**: I31, O55, Q41

# Introduction

Access to electricity remains a development challenge in Africa, with profound implications for socioeconomic well-being and quality of life (Blimpo & Cosgrove-Davies, 2019). Despite global advancements in electrification, the African Great Lakes Countries (GLC), specifically the Democratic Republic of the Congo (DRC), Malawi, Rwanda, Tanzania, and Uganda, continue to experience significant disparities in electricity access, with rural areas disproportionately affected (IEA, 2022). These disparities not only hinder economic growth but also limit opportunities for improved health, education, and overall happiness (Brew-Hammond, 2010; Kelly et al., 2023). The relationship between electricity access and subjective well-being, however, remains underexplored in the context of the GLC, where unique geographical, economic, and infrastructural constraints exacerbate energy poverty (Aklin et al., 2018).

Electricity access in the GLC lags behind global averages, with an average electrification rate of 42% in 2022, compared to 90% in other developing regions (IEA, 2022). In rural areas, this figure drops to just 28%, leaving millions reliant on traditional biomass and kerosene, which pose health and environmental risks (Kakodia et al., 2025). This energy poverty correlates with lower educational attainment, reduced economic productivity, and poorer health outcomes, all of which are determinants of happiness (Helliwell et al., 2012). For instance, households without electricity often face higher exposure to indoor air pollution, a leading cause of respiratory diseases, while limited lighting restricts study hours for children, perpetuating cycles of poverty (Rafa et al., 2024). Furthermore, the absence of reliable electricity stifles entrepreneurial activity, particularly for women, who rely on energy-dependent enterprises for income (Dinkelman, 2011; Das et al., 2020). These challenges emphasize the need to examine how electrification influences happiness in the GLC, where energy access remains a vital yet unresolved issue.

One factor gaining traction in development literature is the role of electricity in enhancing subjective well-being, a measure of happiness and life satisfaction (Graham, 2011; Munir et al., 2024). While studies have linked electrification to economic benefits, its direct impact on happiness is less understood, particularly in resource-constrained settings like the GLC (Stern et al., 2019; Kelly & Radler, 2024). Theoretical frameworks suggest that electricity access may foster happiness by enabling modern amenities (e.g., lighting, refrigeration, and communication technologies), which elevate living standards and reduce daily hardships (Oum, 2019). However, empirical evidence specific to the GLC is sparse, with most research focusing on broader or global samples, potentially obscuring region-specific dynamics.

This study contributes to the literature in two key ways. First, it narrows the focus to the GLC, a region with distinct energy challenges and cultural contexts, thereby avoiding the biases inherent in global analyses that may overlook localized barriers to happiness (Aklin et al., 2018). Unlike prior studies, which often treat the global analyses as a monolith, this research acknowledges the heterogeneity of the GLC, where factors like conflict (e.g., DRC), rapid urbanization (e.g., Rwanda), and agrarian dependence (e.g., Uganda) uniquely shape the electricity-happiness nexus. **Second, the study employs a robust empirical econometric framework to address cross-sectional dependence and endogeneity.** Using **Driscoll-Kraay standard errors** to account for spatial and temporal dependence, and **the Instrumental Variable Two Stage Least Squares** to mitigate endogeneity, the analysis provides evidence that electricity access significantly increases happiness levels in the GLC.

The remainder of the paper is structured as follows: Section 2 reviews the literature on electricity access and well-being, Section 3 outlines the methodology, Section 4 presents and discusses the findings, and Section 5 concludes with policy recommendations.

# Literature Review

The relationship between electricity access and subjective well-being has garnered increasing attention in recent development literature, yet research specifically targeting the African Great Lakes Countries is still limited. Existing studies present differing viewpoints on this relationship; some indicate positive welfare effects, while others point out contextual limitations.

The first strand of literature examines how electricity access and consumption patterns directly influence subjective well-being across different contexts. Nasrudin et al. (2022) provide subnational evidence from Indonesia, where instrumental variable analysis reveals that electricity access boosts happiness through improved housing satisfaction, with particularly strong effects in disadvantaged regions. Similarly, Wu et al. (2022) demonstrate in China that residential electricity consumption enhances well-being across diverse demographic groups, though without detecting nonlinear relationships. These positive findings are complemented by Munir et al. (2024)'s structural equation modeling in Pakistan, which shows how energy-saving behaviors can mediate the relationship between electricity use and well-being. However, Kuziboev et al. (2024) present a more refined perspective from Central Asia, where panel quantile regressions reveal generally negative electricity-happiness relationships that weaken with economic development, emphasizing the importance of stable supply and renewable transitions.

A second body of research focuses on how specific energy system features and economic factors moderate the electricity-well-being relationship. Pfeiffer et al. (2022) take a micro-level experimental approach in Germany, using facial expression analysis to reveal how smart home energy visualizations trigger emotional responses that vary by gender, though graph types show limited differential impacts. At the macroeconomic level, Ostrowska et al. (2024) employ panel models to demonstrate how renewable energy sources in the EU differentially affect both economic growth and happiness, with wind energy showing particularly strong well-being benefits. These technical and systemic factors interact with affordability concerns, as shown by Welsch and Biermann (2017)'s comprehensive European panel analysis, where energy price increases significantly reduce life satisfaction, especially among vulnerable populations during high-demand periods.

While attempts have been made regarding the electricity-happiness nexus across various global contexts, significant gaps remain in understanding how this relationship operates specifically within the unique socioeconomic and geographical landscape of the GLC. Current studies have either focused on broad cross-country analyses that obscure regional particularities or examined individual national cases that lack comparability across the GLC's diverse settings. The present study addresses these limitations by providing the first comprehensive regional analysis of how electricity access influences happiness in the GLC, where distinctive factors like high energy poverty rates, post-conflict recovery dynamics, rapid urbanization patterns, and reliance on both grid and off-grid solutions create a fundamentally different context from previously studied regions. This focused approach fills a knowledge gap in understanding how electrification strategies can be optimized to maximize well-being gains in one of Africa's most complex yet under-researched regional energy landscapes.

# Material and method

##  Data

The data used are from secondary sources, obtained mainly from the World Development Indicators (WDI), and the World Happiness Report (WHR). The data are for 5 African Great Lakes Countries[[1]](#footnote-1), covering the period 2012-2021. The study period is justified by the availability of data, while the study region is justified due to its unique combination of low electrification rates, rapid urbanization, and socio-economic diversity. Despite the region's abundant renewable energy potential, access to electricity remains uneven, with rural areas disproportionately affected, creating a natural experiment to assess how electrification influences well-being (Blimpo & Cosgrove-Davies, 2019). The region's high poverty levels, coupled with its cultural and ecological significance, further emphasize the importance of understanding how improved energy access can enhance happiness, economic opportunities, and social development, making it a compelling case for research. Table 1 displays the descriptive statistics of the study data, where happiness in the study region is averaged at 3.84 on a scale of 0 to 10, with 10 being the highest level of self-satisfaction. Also, Access to electricity in the region has an average of 24.28%, ranging from 7.4% to 48.7%.

Table 1: Descriptive Statistics

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  Variable |  Obs |  Mean |  Std. Dev. |  Min |  Max |
|  Happiness | 50 | 3.849 | 0.457 | 3.207 | 4.762 |
|  Electricity\_Total | 50 | 24.282 | 11.866 | 7.4 | 48.7 |
|  Electricity\_Urban | 50 | 58.572 | 16.213 | 36.6 | 98 |
|  Electricity\_Rural | 50 | 12.494 | 11.797 | 1 | 38.3 |
|  Education | 50 | 3.16 | 1.252 | 1.714 | 6.9 |
|  Financial development | 50 | 18.288 | 3.839 | 10.75 | 26.084 |
|  Health | 50 | 5.347 | 1.57 | 3.052 | 8.224 |
|  Industrialization | 50 | 12.237 | 4.208 | 6.705 | 19.487 |

Source: *Author’s construction*

##  Definition of Variables

### Dependent Variable

This research employs the Cantril ladder score as a measure of happiness, which reflects individuals' subjective well-being. Respondents imagine a ladder where 10 represents their best possible life and 0 their worst possible life, then rate their current life on this scale. The data for this variable are sourced from the Our World in Data repository, following prior research that uses this metric to gauge happiness perceptions (Levin & Currie, 2014). The score represents the national average of life satisfaction ratings, facilitating cross-country analysis. This approach offers a straightforward and comparable method for evaluating life satisfaction across diverse populations.

### Independent Variable

In assessing the effect of electricity access on happiness, we use Access to electricity (% of population) as the primary independent variable. This indicator measures the proportion of a country's population with reliable electricity connections, reflecting the extent of electrification and its potential influence on living standards and well-being. The data for this variable are sourced from the World Development Indicators (WDI) repository, ensuring standardized and comparable cross-country metrics. To further explore disparities in electricity access, we also incorporate Access to electricity as a percentage of rural population, *and* Access to electricity as a percentage of urban population*,* allowing for a refined analysis of rural-urban divides in electrification. These variables are obtained from the same WDI database, which aggregates nationally reported statistics on infrastructure development. We therefore capture both overall electrification rates and subnational variations, providing a comprehensive basis for evaluating how electricity access shapes happiness across different demographic and geographic contexts. Figure 1 displays the evolutionary trend of electricity access in the study region during the study period, where a comparison is made with the average evolution of Sub-Saharan Africa, and the mean of the GLC is found to be inferior to SSA’s mean.



Figure 1: Evolutionary trend of electricity access in African GLC.

*Source:* Author’s construction from Our World in Data

### Control Variables

In addition to the independent variable and in line with the literature on the determinants of well-being, we introduce several control variables into the model, each selected based on strong theoretical and empirical justifications to ensure a robust analysis of the electricity access-happiness nexus. **Education** is included as a control because prior research demonstrates that higher educational investment and attainment enhance cognitive skills, employment opportunities, and overall life satisfaction, which could independently influence happiness levels beyond electricity access (Cuñado & De Gracia, 2012; Kelly & Rutazihana, 2024). **Financial development** is incorporated following evidence (Xu & Sun, 2022; Feuzeu & Kelly, 2025) that well-functioning financial systems improve income stability, access to credit, and economic security, factors that mediate subjective well-being. **Health** is controlled for, as studies (Veenhoven, 2008; Wassou et al., 2024; Kelly & Wassou, 2025) consistently show that better health outcomes, including life expectancy and reduced morbidity, are strongly correlated with higher happiness by enhancing individuals' physical and mental well-being. Finally, **industrialization** is accounted for based on findings that industrial growth affects job creation, income levels, and urbanization patterns, all of which shape living conditions and societal happiness (Nguéda & Kelly, 2022; Inkeles, 2022).

##  Model and Estimation Strategy

Gaining inspiration from the works of Kuziboev et al. (2024), we empirically specify the following model:

$Happiness\_{it}=α\_{0}+α\_{1}Electricity\_{it}+δX\_{it}+µ\_{it}$ (1)

Where $Happiness\_{it}$ is the dependent variable representing the Cantril ladder score for country i at time t. $Electricity\_{it}$*,* representing access to electricity, $X\_{it}$ is the vector of control variables, and $µ\_{it}$ is the stochastic error term.

Two estimation methods are applied in order to ensure valid statistical inference and robust standard errors: The Discroll & Kraay and the Instrumental Variable Two-Stage Least Squares (IV-2SLS). First, we estimate our baseline model using Driscoll & Kraay standard errors due to their ability to address cross-sectional dependence and heteroskedasticity in panel data with a small number of cross-sectional units and a short time dimension. This method is particularly suitable for our study because it produces consistent standard errors even when spatial correlation or serial dependence exists across countries, a common issue in macroeconomic and development studies (Driscoll & Kraay, 1998; Kelly & Nembot Ndeffo, 2025). Given that shocks such as regional economic policies or climate events may simultaneously affect multiple countries in the African Great Lakes region, failing to account for cross-sectional dependence could lead to biased inference. Additionally, Driscoll & Kraay’s nonparametric approach does not impose restrictive assumptions on the covariance structure, making it robust to unknown forms of heteroskedasticity and autocorrelation (Petersen, 2008; Kelly & Ndeffo, 2025). This ensures that our baseline estimates remain reliable despite the limited sample size and potential unobserved common factors influencing both electricity access and happiness.

For robustness and to address potential endogeneity concerns, such as reverse causality (where happier societies may invest more in electrification) or omitted variable bias, we employ the IV-2SLS estimator. This approach is well-suited for small panels where traditional fixed-effects estimators may struggle with weak instruments or finite-sample bias (Baum et al., 2007; Kelly, 2024). The IV-2SLS method allows us to isolate the causal effect of electricity access on happiness while mitigating biases from endogenous regressors (Angrist & Pischke, 2009). By comparing results from both Driscoll & Kraay and IV-2SLS, we ensure that our findings are not driven by estimation artifacts, enhancing the credibility of our conclusions about the electricity-happiness nexus in the African Great Lakes region.

# Results

##  Baseline findings

**Before proceeding with our estimation, we first conduct a cross-sectional dependence test to assess whether unobserved common shocks or spillover effects may introduce bias due to inter-country dependence (Kelly & Radler, 2024). Given the geographic proximity and shared socioeconomic dynamics of the African Great Lakes countries, shocks such as regional policy changes, climate events, or infrastructure investments could simultaneously influence multiple nations in our sample (Kelly et al., 2022;** Kelly & Ketu, 2024**). To ensure the validity of our inference, we specifically test for weak cross-sectional dependence, which examines whether correlations between countries diminish as the sample size increases. The results of this test, presented in Table 2, confirm the presence of cross-sectional dependence, guiding our choice of the Driscoll-Kraay standard errors estimation technique.**

**Table 2:** Tests of weakly cross-sectional dependence

|  |  |
| --- | --- |
|   | Testing for weak cross-sectional dependence (CSD)H0: weak cross-section dependenceH1: strong cross-section dependence |
|  CD |  CDw+ |
| Happiness  |  0.320 |  7.930 |
|  | (0.000) | (0.000) |
| Electricity\_Total  |  7.980 |  23.970 |
|  | (0.000) | (0.000) |
| Education |  0.270 |  9.520 |
|  | (0.005) | (0.000) |
| Financial development |  0.120 |  10.940 |
|  | (0.000) | (0.000) |
| Health  |  0.190 |  8.610 |
|  | (0.009) | (0.000) |
|  Industrialization  |  0.530 |  18.000 |
|  | (0.000) | (0.000) |

Source: *Author’s Construction.* **Notes:** p-values in parenthesis.

The results from Table 3, estimated using Driscoll & Kraay standard errors, reveal a statistically significant and positive relationship between electricity access and happiness across all specifications. Total electricity access (column 1), indicates that a one-unit increase in electricity access is associated with a 0.169-unit increase in happiness, all else equal. This aligns with existing literature, such as that of **Graham and Pettinato (2002)**, who argue that access to basic infrastructure like electricity enhances well-being by improving living standards and opportunities for economic activities. The effect is even more pronounced in rural areas (column 3), compared to urban electrification (column 2). This disparity suggests that rural populations derive greater marginal utility from electricity access, likely due to the transformative impact of electrification in areas previously lacking basic amenities. The larger effect in rural areas corroborates findings by **Lee et al. (2020)**, who highlight that electrification in underserved regions can significantly reduce poverty and improve quality of life. The statistical significance of these coefficients underscores the robustness of the results, and the larger magnitude for rural areas may reflect diminishing marginal utility in urban settings where electricity access is already more widespread. Economically, these results imply that policies targeting rural electrification could yield higher happiness returns per unit of investment compared to urban electrification, supporting targeted infrastructure development in underserved regions.

Table 3: Effect of Electricity access on Happiness-Discroll & Kraay Estimates

|  |  |  |  |
| --- | --- | --- | --- |
|  | (1) | (2) | (3) |
| VARIABLES | Happiness | Happiness | Happiness |
|  |  |  |  |
| Electricity\_Total  | 0.169\*\*\* |  |  |
|  | (0.0434) |  |  |
| Electricity\_Urban  |  | 0.0755\*\* |  |
|  |  | (0.0388) |  |
| Electricity\_Rural  |  |  | 0.332\*\*\* |
|  |  |  | (0.0430) |
| Education | 0.574\*\*\* | 0.726\*\*\* | 0.813\*\*\* |
|  | (0.0565) | (0.0628) | (0.0468) |
| Financial development | 0.0163\*\*\* | 0.0121\*\*\* | 0.0652\*\* |
|  | (0.00307) | (0.00315) | (0.0265) |
| Health |  0.528\*\*\* |  0.521\*\*\* |  0.525\*\*\* |
|  | (0.0222) | (0.0246) | (0.0217) |
| Industrialization  | 0.0915\*\*\* | 0.0948\*\*\* | 0.0942\*\*\* |
|  | (0.0109) | (0.00747) | (0.0127) |
| Constant | 2.574\*\*\* | 2.473\*\*\* | 2.559\*\*\* |
|  | (0.567) | (0.374) | (0.619) |
|  |  |  |  |
| Observations | 50 | 50 | 50 |
| R-squared | 0.581 | 0.581 | 0.583 |
| Number of groups | 5 | 5 | 5 |

Source: *Author’s construction*

*Notes: Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.*

The control variables in Table 3 exhibit statistically significant and theoretically consistent relationships with happiness. Education has a strong positive effect across all specifications, supporting the notion that higher education levels enhance well-being by increasing earning potential and opportunities, as noted by **Oreopoulos and Salvanes (2011) and** Kelly and Rutazihana (2024). Financial development also shows a positive and significant relationship, consistent with studies like **Beck et al. (2007) and** Feuzeu and Kelly (2025), which link financial inclusion to improved economic security and happiness. Health, measured using healthcare expenditure, has a large positive coefficient, aligning with **Easterlin (2003)**’s findings on the importance of health for subjective well-being. Industrialization exhibits a positive and significant effect, reflecting its role in job creation and income growth, as discussed by **Clark et al. (2008)**. Overall, the signs and significance of these controls corroborate existing literature, reinforcing the validity of the model and its findings.

##  Endogeneity Account

The IV-2SLS estimates in Table 4 address potential endogeneity in the relationship between electricity access and happiness, providing more robust causal inferences. The results confirm and even amplify the positive effect of electricity access on happiness compared to the baseline Driscoll & Kraay estimates. Total electricity access (column 1) now shows a larger coefficient, suggesting that accounting for endogeneity reveals a stronger impact of electrification on well-being. This aligns with Burgess et al. (2020), who argue that instrumental variable approaches often uncover larger effects by isolating exogenous variation in infrastructure access.

The rural-urban disparity persists, with rural electrification (column 3) exhibiting a substantially larger coefficient than urban electrification. This reinforces the baseline finding that rural populations benefit more from electrification, likely due to the absence of alternatives (e.g., generators) and the transformative role of electricity in enabling education, healthcare, and income-generating activities (Lee et al., 2020). The smaller urban effect may reflect saturation or substitution effects, where urban households already have partial access. The statistical significance across all specifications underscores the robustness of the results, supporting policy prioritization of rural electrification for maximizing happiness gains. Regarding the control variables, their signs and statistical significance corroborate previous findings.

Table 4: IV-2SLS estimates

|  |  |  |  |
| --- | --- | --- | --- |
|  | (1) | (2) | (3) |
| VARIABLES | Happiness | Happiness | Happiness |
|  |  |  |  |
| Electricity\_Total  | 0.382\*\*\* |  |  |
|  | (0.0271) |  |  |
| Electricity\_Urban  |  | 0.0508\*\* |  |
|  |  | (0.0213) |  |
| Electricity\_Rural  |  |  | 0.455\*\*\* |
|  |  |  | (0.0248) |
| Education | 0.261\*\*\* | 0.110\*\*\* | 0.276\*\* |
|  | (0.0156) | (0.0193) | (0.136) |
| Financial development | 0.0540\*\*\* | 0.0514\* | 0.0794\*\* |
|  | (0.00921) | (0.0374) | (0.0350) |
| Health | 0.401\*\*\* | 0.615\*\*\* | 0.387\*\*\* |
|  | (0.0588) | (0.0568) | (0.0483) |
| Industrialization  | 0.124\*\*\* | 0.106\* | 0.111\*\*\* |
|  | (0.0323) | (0.0561) | (0.0265) |
| Constant | 1.547\*\*\* | 2.145\*\*\* | 2.916\*\*\* |
|  | (0.020) | (0.705) | (0.796) |
|  |  |  |  |
| Observations | 50 | 50 | 50 |
| R-squared | 0.512 | 0.575 | 0.562 |

Source: *Author’s construction*

*Notes: Standard errors in parentheses; \*\*\* p<0.01, \*\* p<0.05, \* p<0.1.*

# Conclusion and Policy Recommendations

The findings of this study emphasize the crucial role of electricity access in promoting happiness, particularly in the African Great Lakes Countries, where energy poverty is a persistent challenge. The strong positive relationship between electrification and subjective well-being, especially in rural areas, highlights the transformative potential of electricity in improving living standards, health outcomes, and economic opportunities. The larger marginal utility observed in rural electrification suggests that underserved populations derive greater well-being benefits from access to electricity, likely due to the absence of alternatives and the foundational role of energy in enabling education, healthcare, and income-generating activities. The consistency of these results across both baseline and IV-2SLS estimations strengthens the causal interpretation, demonstrating that electrification is not merely correlated with happiness but actively contributes to it. These insights align with broader development literature while emphasizing the unique context of the GLCs, where infrastructural deficits and regional disparities exacerbate the challenges of energy access.

To maximize the happiness benefits of electrification, policymakers in the GLCs should prioritize rural energy access through targeted infrastructure investments, leveraging the disproportionate well-being gains observed in these areas. Programs such as decentralized renewable energy solutions, including solar mini-grids and off-grid systems, could rapidly expand access while avoiding the high costs and delays associated with grid extension. Complementary measures, such as subsidies for low-income households and partnerships with private sector actors, could further enhance affordability and adoption. Urban electrification efforts should focus on improving reliability and reducing outages, as saturation effects may limit the marginal happiness gains of expanding access in already-connected areas. Additionally, integrating electrification with other development initiatives, such as education campaigns, healthcare infrastructure, and financial inclusion programs, could amplify its positive spillovers. Regional cooperation among GLCs, facilitated by shared energy pools and cross-border grid interconnections, could optimize resource allocation and reduce costs. Finally, governments should establish strong monitoring frameworks to evaluate the well-being impacts of electrification projects, ensuring that policies remain evidence-based and responsive to local needs.

While this study provides strong evidence on the electricity-happiness nexus in African GLCs, it has the limitation of relying on national-level data, which may mask subnational heterogeneity. Future research could expand the analysis to include household-level surveys and explore nonlinear effects of electrification. Additionally, comparative studies across other African regions could contextualize these findings and inform broader policy frameworks.

**Data Availability Statement:** The data underlying this article will be shared on request.

**Conflicts of Interest:** The authors have no known conflicts of interest to declare.

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