Energy Access and Income Inequality: A Cross-Sectional Analysis of Developing Countries

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Abstract

Progress towards the 2030 Sustainable Development Goals depends on simultaneous efforts to reduce income inequality and ensure access to affordable, reliable, and modern energy. This study investigates the impact of energy access on income inequality, utilising cross-country data from 24 countries. It employs the Ordinary Least Squares estimation technique. It finds that a one percentage point increase in the share of the population with access to electricity is associated with a 0.27-point reduction, on average, in the Gini index (keeping other factors constant). It also shows that higher social contributions as a share of government revenue are significantly associated with lower income inequality. The results highlight the importance of combining energy-related interventions with fiscal and social protection policies to achieve more equitable development outcomes.

JEL Classification: D63; O13; Q43; O15

Keywords: Income Inequality, Electricity Access, Social Contributions, Economic Growth, Cross-country Analysis

Introduction

Despite substantial advances in global economic development, poverty and inequality persist as enduring challenges. According to the World Inequality Report (2026), the top 10% (about 560 million adults) receive 53% of global income, while the bottom 50% (roughly 2.8 billion adults) capture only 8%. Diving deeper, the concentration becomes staggering. The top 1%, roughly equivalent to the adult population of the United Kingdom, alone control 37% of global wealth. However, for the first time, all members of the United Nations (UN) placed the reduction of inequality at all levels at the center of global policy priorities by introducing Sustainable Development Goal 10. Income inequality is not just an economic issue, but it is also a moral concern. This is why governments and international institutions are

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increasingly being urged to take action to reduce it (DESA, 2025). If large income gaps are left unaddressed, they can lead to social unrest and economic instability, making it even harder to reduce poverty. It weakens the growth elasticity of poverty reduction (Galbraith, 1958). Many economists hold the belief that higher economic growth trickles down through society, thereby reducing income inequality.

However, given the complexity of the concept, the growth figures alone are insufficient to explain the widening gaps. This study, therefore, seeks to go beyond traditional economic growth metrics and asks whether access to energy is a crucial factor in reducing income inequality.

Motivation

The relevance of this question to knowledge and policymaking is evident in the 2030 Agenda for Sustainable Development, which establishes the first universal energy goal. It is essential to note that the Millennium Development Goals did not include an energy objective. Furthermore, the World Bank recognizes energy as the heart of development, prompting the launch of the Lighting Global program, which has allocated over $5 billion to enhance energy access across various developing countries.

According to the World Energy Outlook (2025):

Modern energy access includes household access to a minimum level of electricity, initially equivalent to 250 kilowatt-hours (kWh) annual demand for a rural household and 500 kWh for an urban household; household access to less harmful and more sustainable cooking and heating fuels, and improved/advanced stoves; access that enables productive economic activity; and access for public services (World Energy Outlook, 2025, p. 484)

Energy access plays a key role in reducing income inequality by strengthening people's capabilities and enabling them to participate more fully in economic and social life (UNDP, 2018). In other words, when people, especially those who are less well-off, gain access to energy, they can build up their own resources and narrow the income gap. Additionally, access to energy can improve health, education, employment opportunities, gender equality, and agricultural practices, all of which can help reduce income inequality.

Literature Review

The relationship between energy access, economic growth, and inequality is a multifaceted issue. To ensure that every individual has access to modern, affordable, and dependable energy, countries prioritize reducing income inequality in line with the 2030 Global Goals. This review synthesizes recent research to elucidate the bidirectional relationship between energy access and economic inequality, explores the regional and social dimensions, and highlights policy pathways to advance both energy equity and economic justice.

Causal Mechanisms Linking Energy Access and Economic Inequality

Energy access and economic inequality are linked through multiple complex causal pathways. Limited access to modern energy services (electricity, clean cooking) restricts economic opportunities, exacerbates income disparities, and perpetuates poverty, especially in rural and disadvantaged regions by repressing agricultural productivity, constraining small business development, and impairing access to education and health services, thereby, deepening the economic disparities (López, 2025; Ghosh, 2025; Ma & Njangang, 2025; Opoku et

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al., 2025). Urban areas typically benefit from denser grids, lower connection costs, and better service reliability, while rural regions face limited coverage, higher per-unit costs, and poorer service quality. This urban-rural divide is further exacerbated by infrastructure gaps resulting from high capital costs, dispersed settlements, challenging terrain, and weak incentives for private and public investment in rural areas (Mekonnen & Sarwat, 2017; Falchetta, 2021). Urbanisation patterns and access to urban opportunities are often linked to access to energy and infrastructure, and therefore can influence income gaps. Specifically, in regards to state-level inequality, the city-size distribution becomes a crucial factor. A higher concentration of people in large cities (urban concentration) tends to increase state-level inequality, whereas a concentration in small towns tends to lower it (Tripathi & Yenneti, 2024).

Several studies indicate that trade patterns tend to distribute economic benefits and energy burdens unevenly. International energy trade often favours developed regions while energy-intensive production is outsourced to developing areas (Pang et al., 2024). This shift increases local energy burdens without commensurate economic gains, thereby reinforcing regional inequality (Chen et al., 2025; Falchetta, 2021; Mekonnen & Sarwat, 2017; Pang et al., 2024).

Beyond macro-level trade dynamics, energy access and inequality are also mediated through entrenched socioeconomic structures within countries. Evidence from rural India suggests that caste and wealth significantly predict both electricity access and the adoption of decentralized renewable technologies, such as solar home systems, even after large-scale electrification initiatives were implemented post-2015 (Cieslik, 2016). Wealthier households are not only more likely to obtain initial access but also better positioned to sustain the use of renewable energy technologies, while marginalized households face persistent barriers (Biswas et al., 2022; Dugoua et al., 2017). The extent to which expanded energy access translates into equitable economic outcomes further depends on the quality of supporting infrastructure and governance institutions. Strong regulatory quality, transparency, and inclusive governance are crucial for the effective implementation of energy access interventions (Sainati et al., 2023).

Studies from Sub-Saharan Africa, including those by Sarkodie and Adams (2020), demonstrate that income inequality adversely affects human development outcomes and that social protection programmes play a crucial moderating role in this relationship. Social protection mechanisms—such as unemployment benefits, old-age pensions, disability transfers, and other safety nets—are identified as key instruments for reducing household vulnerability and preventing socioeconomic deprivation from becoming persistent and intergenerational.

Though the energy access generally promotes development, its distributional effects (and thus its likely impacts on inequality) can vary across regions. Acheampong et. al. (2021) examine human development rather than inequality per se, using panel data for 79 “energy-poor” countries across South Asia, sub-Saharan Africa, and Latin America/Caribbean. The findings show that, after accounting for several complementary factors—economic growth, trade openness, FDI, urbanisation, credit access, and remittances—both electricity and access to clean energy significantly improve overall human development through various channels (employment, industrialisation, Information and Communication Technology, and gender empowerment). Interestingly, their regional breakdown shows positive development impacts in the Caribbean and Latin America, as well as sub-Saharan Africa, but negative effects in South Asia. Sarkodie and Adams et al. (2020) demonstrate that electricity access, human development, and income distribution form a tightly connected system: regions with better access to electricity tend to exhibit higher human development, while areas with limited access show persistent inequality. Their analysis underscores that energy access is not merely a technological variable but a foundation for inclusive development. Other studies demonstrate the joint effect of education and energy access on income inequality. Owolabi et al. (2024), studying Nigeria, find that electricity access plays a statistically significant role in reducing inequality in the short run. In contrast, education alone does not produce an immediate equalising effect. Their work emphasizes that electrification enables modern-sector activities that disproportionately benefit households previously excluded from such opportunities. Parallel evidence from India's urbanisation dynamics, examined by Tripathi and Yenneti et al. (2024), indicates that rising educational attainment does not automatically reduce inequality in contexts where labour markets are segmented or where access to quality education remains uneven. Their findings suggest that expansions in employment opportunities and reductions in structural barriers must accompany improvements in enrolment. Similarly, studies from South Africa and Indonesia treat education mainly as part of broader development pathways influenced by energy access and institutional conditions rather than as a direct determinant of inequality.

Energy Access and Developmental Heterogeneity

Song et al. (2023) distinguish between access to electricity, clean cooking fuels, and renewable energy development, and examine how each relates to income inequality at different stages of development. Using panel data for 77 countries over the period 2000–2019, they demonstrate that greater access to electricity significantly reduces income inequality. In contrast, access to clean fuels and renewable energy development may initially exacerbate inequality, particularly in countries at lower and middle stages of development. Their findings suggest that while basic electrification alleviates income disparities by easing time and income constraints faced by poorer households, the benefits of clean fuels and renewable energy are unevenly distributed due to high adoption costs and technological barriers. Incentive schemes for clean energy development in developing nations are often not sufficiently designed, disproportionately affecting the poor. Notably, the study identifies public health improvements and higher educational attainment as key transmission mechanisms through which reductions in energy poverty translate into lower income inequality. As economies advance, renewable energy development emerges as a more effective equalising force, highlighting the dynamic and stage-dependent nature of the energy–inequality nexus.

Micro-level Analyses

Moreover, much of the available evidence on energy access is based on micro-level analyses or country-specific studies, which, although rich in contextual detail, limit the ability to generalize findings across diverse institutional and socioeconomic settings. For instance, da Silveira Bezerra et al. (2017) provide micro-level evidence from Brazil, demonstrating that access to electricity

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improves human development in the country's poorest regions. Awaworyi Churchill and Smyth (2021) document a negative association between energy poverty and general health in Australia, while Njiru and Letema (2018) demonstrate that energy poverty negatively impacts living standards, calorific intake, life expectancy, and literacy outcomes in Kirinyaga, Kenya. Sambodo and Novandra (2019), using village-level data, find that access to electricity and modern cooking fuels contributes to reductions in malnutrition. Oum (2019) similarly finds that energy poverty significantly lowers educational attainment and health status among households in Lao PDR. Hardi et al. (2025), analysing Indonesia, show that increased access to renewable energy reduces the depth and severity of poverty, thereby narrowing distributional gaps. Although their dependent variables are poverty measures rather than the Gini coefficient, the mechanism that shows that greater energy access reduces deprivation is consistent with global findings. It also emphasizes the role of redistribution and institutional support in enhancing the impact of economic growth and energy access in reducing poverty gaps. They show that renewable-energy programmes are more effective when supplemented with wider welfare and infrastructure investments. The global literature, therefore, views redistributive fiscal capacity, whether through transfers, pensions, or social insurance, as a key determinant of whether development translates into more equal outcomes.

Economic Growth and Inequality

Globally, economists typically believe that there is a non-linear relationship between economic development and inequality. Studies based on the Kuznets hypothesis argue that inequality tends to rise in the early to mid-stages of economic growth before stabilising at higher income levels. This pattern appears in several developing regions. For instance, work by Owolabi *et al.* (2024) on Nigeria situates inequality within the broader context of structural transformation, where growth disproportionately benefits skilled workers and capital-intensive sectors. However, most empirical research has not established a systematic Kuznets relation. This is evident in the recent rise in income disparities even in developed economies (Bourguignon, 2015). Consistent with this pattern, Alvaredo et al. (2018) show that since 1980, the richest 1 per cent of the global population has captured approximately twice the share of economic growth accrued by the bottom 50 per cent. These findings suggest that while economic growth may be a necessary condition for improving overall economic performance, it is not sufficient to ensure a more equitable distribution of income. This perspective aligns with Sen's (1980, 1988) argument that economic growth alone does not automatically translate into improvements in people's well-being.

This study makes a significant contribution to the existing literature in several important ways by directly addressing key gaps in prior research. First, while much of the empirical literature has relied on micro-level or country-specific analyses focusing on the effects of energy access on growth or human development outcomes, this study provides a cross-country assessment of the relationship between energy accessibility and income inequality. It focuses explicitly on electricity accessibility as the key independent variable. In addition, this study makes a novel contribution by explicitly incorporating social contributions–as a share of government revenue–into the analysis of income inequality. While existing research often considers aggregate social spending or social protection coverage,

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few studies examine the distributive role of social contributions within governments' fiscal structures. By capturing the extent to which governments mobilize resources through social insurance mechanisms, this measure provides a more nuanced understanding of how fiscal capacity and redistribution interact with energy accessibility to shape income inequality outcomes.

Research Objective

To empirically examine how access to energy affects economic inequality in emerging (developing) countries by estimating the impact of access to electricity on the Gini coefficient (index) using cross-country regression analysis.

Data and Methodology

Data Sources

This study conducts a cross-sectional analysis using country-level data sourced from the World Development Indicators Database (WDI, https://databank.worldbank.org/) for 2023, except for India, for which data for all variables are for 2022.

Table 1 - Sample of the study

Income Group	Number of Countries	Countries
Low Income	1	Rwanda
Lower-Middle Income	9	India, Jordan, Kenya, Kyrgyz Republic, Namibia, Senegal, Sri Lanka, Tajikistan, Uzbekistan
Upper-Middle Income	12	Albania, Argentina, Belarus, Bosnia and Herzegovina, Dominican Republic, El Salvador, Guatemala, Mexico, Moldova, North Macedonia, Paraguay, Thailand
High Income	2	Costa Rica, Russian Federation

Study Sample

The study analyses 24 developing/emerging countries, representing a wide range of income groups (as classified by the World Bank) and geographic regions.

The sample includes low-, lower-middle-, upper-middle-, and high-income economies across South Asia, Sub-Saharan Africa, Latin America and the Caribbean, Europe and Central Asia, the Middle East and North Africa, and East Asia and the Pacific. The countries are selected based on data availability (see Table 1). Despite data limitations, the sample provides a reasonably representative coverage of developing economies across these regions.

Variables Description

Dependent Variable

In the study, the outcome variable taken is the country's Gini index.

The Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution (WDI). A Lorenz curve plots the cumulative percentages of total income received against the cumulative number of recipients, starting with the poorest individual or household. The Gini index measures the area between the Lorenz curve and a hypothetical line of absolute equality, expressed as a percentage of the maximum area that could be achieved under the line (WDI). Thus, a Gini index of 0 represents perfect equality, while an index of 100 implies perfect inequality. See Figure 1 for the distribution of the dependent variable across the countries.

Explanatory Variables

i. Access to Electricity (% share of Population): Access to electricity is the percentage of the population with access to electricity.

Source: WDI Dataset, which draws on the SDG 7.1.1 Electrification Dataset from the World Bank (WB). Electrification data are collected from industry, national surveys, and international sources.

Rationale – Access to electricity is a core indicator of energy accessibility and energy poverty, reflecting the extent to which households can meet basic energy needs for lighting, communication, education, healthcare, and productive activities. By enabling income-generating activities and improving human capital outcomes, electricity access can reduce income disparities, especially in developing economies. See Figure 2.

ii. Social contributions (% of Government revenue): Social contributions are actual or imputed contributions payable to social insurance schemes to make provisions for social benefits to be paid. This indicator is expressed as a percentage of revenue, which includes all transactions that add to the amount of economic value of a unit or sector.

Source – WDI Dataset, which obtains data from the Government Finance Statistics Yearbook and data files, International Monetary Fund (IMF).

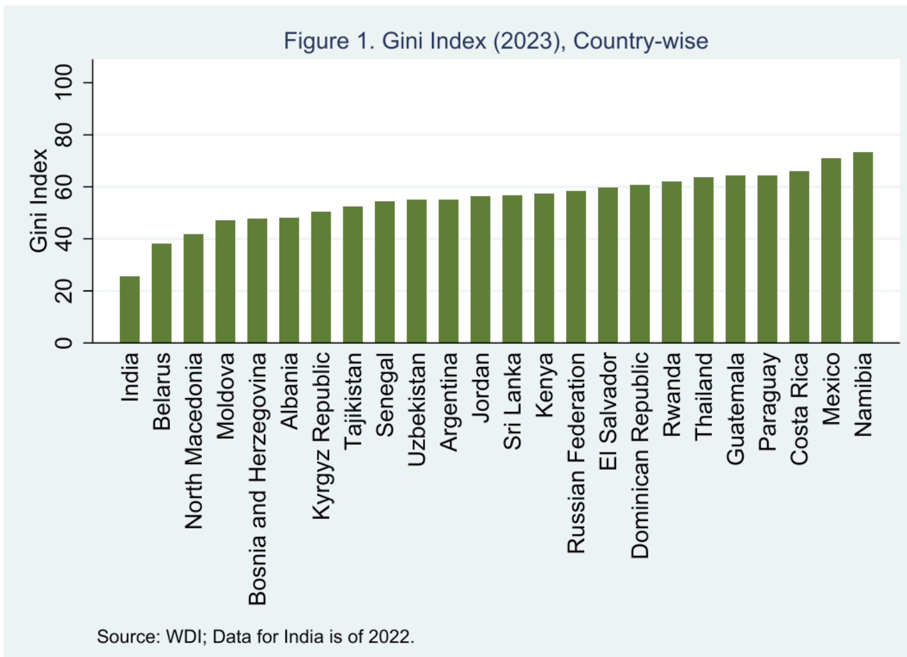
Rationale – Social contributions as a percentage of government revenue capture the strength and coverage of a country's social insurance and social protection system. It reflects the fiscal capacity and institutional depth of social protection systems. Higher social contributions mean a greater capacity of the state to mobilize resources for pensions, unemployment benefits, health insurance, and other social security programmes that protect households against income and energy-related shocks. By redistributing income and reducing vulnerability among low- and middle-income groups, stronger social contribution systems can play a crucial role in mitigating income inequality. Including this variable enables the study to assess how fiscal and social protection capacity interact with energy access to shape income distribution outcomes. See Figure 3.

iii. Gross Domestic Product (GDP) per capita (constant 2015 US$): Gross domestic product is the total income earned through the production of goods and services in an economic territory during an accounting period (WDI). The core indicator has been divided by the general population to achieve a per capita estimate. This indicator is expressed in constant prices, meaning the series has been adjusted to account for changes in prices over time. The reference year for this adjustment is 2015. This indicator is expressed in United States dollars.

This study uses the logarithm of GDP per capita to account for diminishing marginal effects of income on inequality and energy access, consistent with the non-linear relationship suggested by the Kuznets hypothesis. Controlling for the log of GDP per capita ensures that observed effects are not driven solely by differences in overall income levels.

Source – WDI Dataset, which obtains data from Country official statistics, National Statistical Organisations, and/or Central Banks.

Rationale – GDP per capita serves as a standard proxy for a country's average income level and overall stage of economic development. Controlling for GDP per capita is essential, as income inequality and access to energy are closely linked to economic development. See Figure 4.



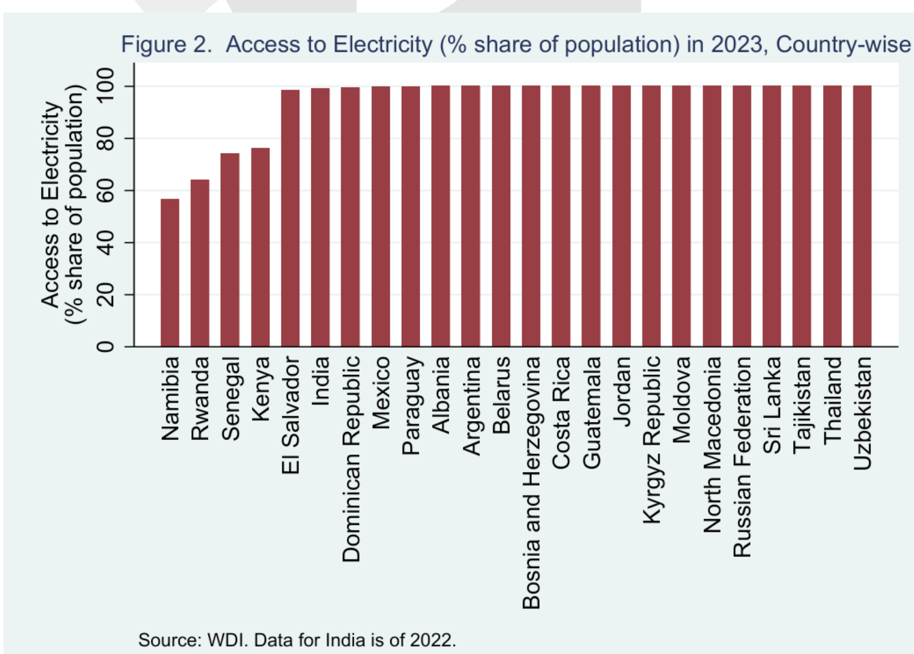
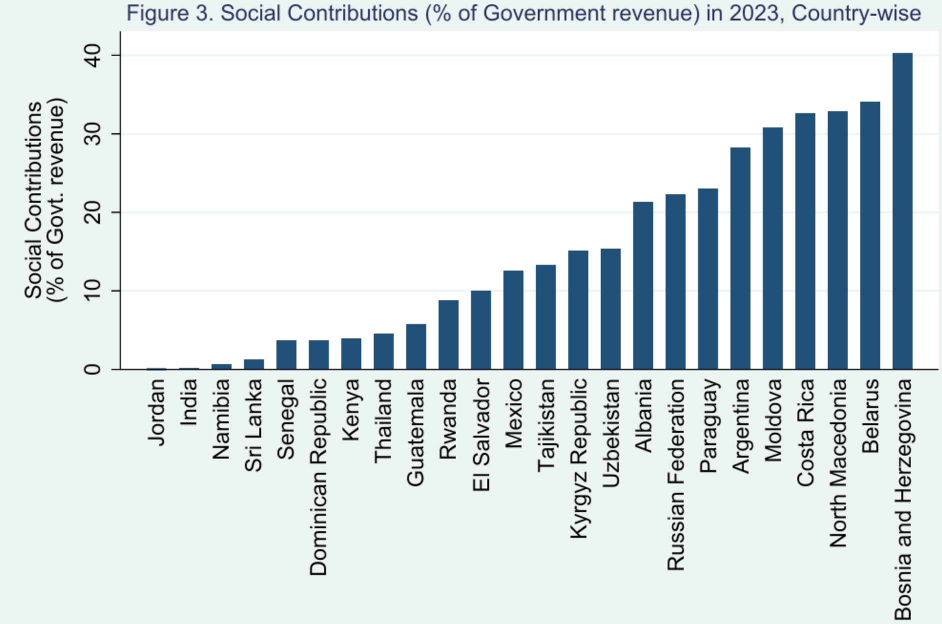
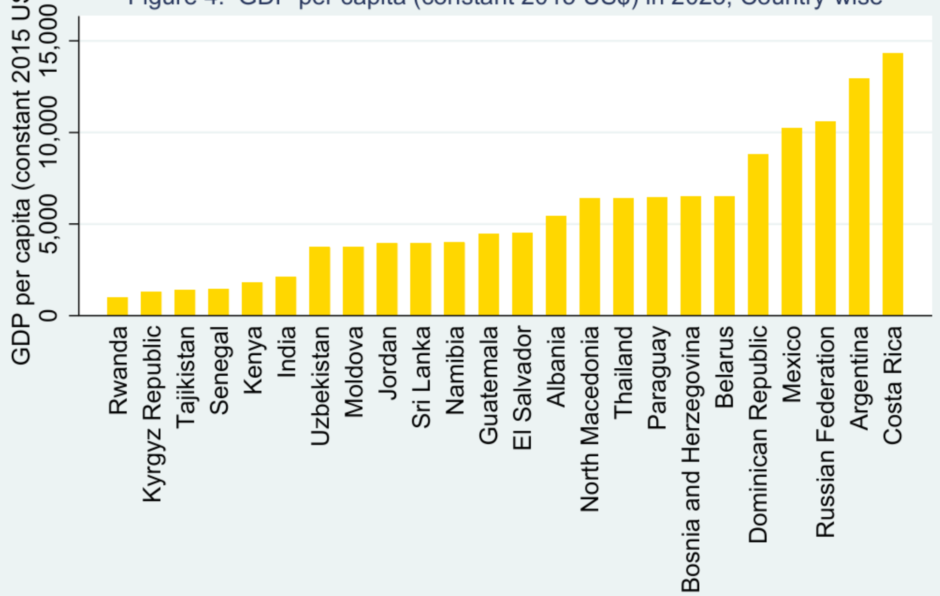


Figure 3. Social Contributions (% of Government revenue) in 2023, Country-wise



Source: WDI. Data for India is of 2022.

Figure 4. GDP per capita (constant 2015 US$) in 2023, Country-wise



Source: WDI. Data for India is of 2022.

Descriptive/Statistical Analyses

Statistical analyses were performed to investigate the factors associated with income inequality across the sample countries. Table 2 reports the descriptive statistics for the key variables included in the regression analysis.

Table 2 - Summary Statistics of variables included in the study.

Variable Code	Description	N	Mean	S.D.	Min	Max
Y (Dependent)						
Inc_Inequality	**Gini Index**	**24**	**55.29**	**10.60**	**25.5**	**73.09**
X (Explanatory)						
ElecAccess	Access to Electricity (% share of Population)	24	94.48	12.655	56.7	100
SocialContri	Social contributions (% of Govt. revenue)	24	15.13	12.67	0.057	40.18
GDPpc	GDP per capita (constant 2015 US$)	24	5499.48	3660.38	1004.33	14318.84

Source: Author's Estimation

(See Appendix for Graphs of the variables.)

Model Specification

The study estimates a multiple linear regression model as a base model to examine the impact of energy access on the Gini coefficient. Several estimations were performed during the process, but only those that passed the goodness-of-fit tests were retained. Ordinary Least Squares (OLS) estimation is used to assess the relationship between the dependent and explanatory variables. All variables are at the country level. All analyses were conducted using STATA software. The empirical model is specified as follows:

$$Inc\_Inequality_i = \boldsymbol{\alpha} + \boldsymbol{\beta_1}\, ElecAccess_i + \boldsymbol{\beta_2}\, SocialContri_i + \boldsymbol{\beta_3}\, ln(GDPpc)_i + \boldsymbol{\varepsilon_i}$$

The subscript i represents country i.

Research Hypothesis

Based on the theoretical framework and existing empirical literature, the study advances the following hypotheses regarding the expected signs and effects of the estimated coefficients:

H1: Access to electricity () is expected to have a negative and statistically significant effect on income inequality.

Greater access to electricity is expected to reduce the Gini coefficient by expanding economic opportunities, enhancing productivity, and improving access to education and healthcare, particularly for lower-income households.

H2: Social contributions as a percentage of government revenue () are expected to be negatively associated with income inequality.

Higher social contributions reflect stronger social insurance and redistribution mechanisms, which are expected to mitigate income inequality.

Empirical Results

Table 3 presents the results of the multiple linear regression analysis examining the relationship between energy access, social contributions, and income inequality, measured by the Gini index. The model demonstrates strong explanatory power, with an R^2 value of 0.734 and an adjusted R^2 of 0.678, indicating that approximately 73%

of the variation in income inequality across the sampled countries is explained by the included explanatory variables.

Access to electricity shows a negative and statistically significant association with income inequality. The coefficient on access to electricity is –0.271 and is significant at the 5% level. This result supports the expectation that improved electricity access enhances productive opportunities, human capital formation, and access to essential services, particularly for disadvantaged populations, thereby reducing income disparities.

Social contributions as a percentage of government revenue also have a highly significant adverse effect on income inequality. The estimated coefficient of –0.450 is significant at the 1% level, indicating that stronger social insurance and redistribution mechanisms play a crucial role in reducing income inequality. This finding underscores the significance of fiscal capacity and social protection systems in mitigating household economic vulnerabilities and redistributing income more equitably.

Table 3 – Regression Results

Dependent Variable: Income Inequality	**Gini Index (Inc_Inequality)**
Access to Electricity (% share of Population)	-0.271**
(ElecAccess)	(0.120)
Social contributions (% of Govt. revenue)	-0.450***
(SocialContri)	(0.118)
Log of GDP per capita (constant 2015 US$)	7.281***
ln(GDPpc)	(2.078)
Dummy: India	-31.30***
	(6.613)
Constant	28.06*
	(15.84)
No. of observations	24
R2	0.734
Adjusted R2	0.678

Source: Author's estimation

Note: Standard errors in parentheses. ***, **, and * represent significance at 1%, 5%, and 10% levels, respectively.

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In contrast, the coefficient on the logarithm of GDP per capita is positive and statistically significant at the 1% level. From an econometric perspective, this finding is consistent with the upward-sloping segment of the Kuznets curve, where economic growth initially exacerbates income inequality before redistributive mechanisms, institutional maturity, and broader access to opportunities begin to reduce disparities at later stages of development. Given that, most of the sampled countries are predominantly emerging and developing economies, that is, low-, lower-middle-, or upper-middle-income economies, the positive association between GDP per capita and income inequality reflects this transitional phase of development rather than a contradiction of long-run convergence theories. In the early stages, increases in average income often coincide with structural transformation, where the benefits of growth are unevenly distributed across sectors, regions, and population groups. Economies undergo shifts from agriculture to industry and services, experience rising skill premiums, and face uneven access to formal employment and capital markets. As a result, income gains tend to be concentrated among specific groups, widening income disparities even as per capita income rises.

The coefficient on the India dummy variable is negative and statistically significant at the 1% level. This indicates that, after controlling for other factors, India's observed level of income inequality is significantly lower than that of the reference group of countries in the sample. However, this result must be interpreted with caution due to differences in the data reference year. India's data are from 2022, while the remaining countries' data are from 2023. As a result, the dummy coefficient may partly capture time-specific effects, such as differences in macroeconomic conditions, post-pandemic adjustment paths, or short-term policy interventions that affected income distribution in 2022 but not uniformly in 2023. In econometric terms, the India dummy absorbs both country-specific structural characteristics and unobserved year-specific variation, since the model does not include a separate time-control variable.

Interpretation of coefficients

- Access to Electricity - % (share) of population

  A one percentage point increase in the share of the population with access to electricity is associated with a **0.271-point reduction** (on average) in income inequality, as measured by the Gini index, while holding other factors constant.

- Social contributions (% of government revenue)

  A one percentage point increase in social contributions as a share of government revenue is associated with a **0.450-point decrease** (on average) in the Gini Index, ceteris paribus.

- Log of GDP per capita (constant 2015 US$):

  A 1% increase in GDP per capita is associated with an increase of approximately **0.073 points** (on average) in the Gini index, holding other variables constant.

Diagnostic Checks: Heteroscedasticity and Outliers

A thorough diagnostic assessment was performed to ensure the regression's reliability.

Heteroskedasticity (Non-constant Error Variance)

The Breusch–Pagan test was used to check for heteroskedasticity in the regression model.

The test statistic yields a chi-square value of 0.01 with a corresponding p-value of 0.9393. Since the p-value is much greater than 0.05, the research fails to reject the null hypothesis. This means there is no statistical evidence of heteroskedasticity in the model. The model satisfies the assumption of constant error variance.

Influential Outliers

Given the cross-country nature of the dataset and the relatively small sample size, the diagnostic checks were performed. It identified India as a potentially influential case due to its distinct economic and demographic characteristics and the use of 2022 data, rather than 2023, for other countries. The study includes a separate dummy variable for India in the model. This approach controls for unobserved country- and time-specific effects while preserving the integrity of the sample.

Reasons for India exerting disproportionate influence –

India differs fundamentally from most countries in the sample in terms of population size, economic scale, and labour market structure. According to World Bank data (2025), India's Gini Index fell from 28.8 in 2011 to 25.5 in 2022. The pandemic period (2020-2022) noted a temporary effect where the incomes of the rich, particularly in urban areas (e.g., permanent salaried workers who lost jobs and struggled to find comparable ones quickly), dropped at a faster rate or recovered slower than those of informal workers who could transition to other jobs (like agriculture), which skewed the immediate income distribution dynamics. India led large-scale welfare and short-term redistributive interventions, including the free food grain distribution under the PM Garib Kalyan Anna Yojana (PMGKAY), which was launched during the COVID-19 pandemic. Direct benefit transfers ensured timely support to the most vulnerable sections of society. By protecting low-income households through food support, employment guarantees, and price stabilisation, these schemes helped prevent the churning poor from falling back into extreme poverty.

Discussion – Policy Implications

The findings of this study offer important policy implications for addressing income inequality, particularly in emerging and developing economies. The results suggest that economic growth alone is insufficient to ensure equitable income distribution, and that complementary policies targeting energy access and social protection are essential for inclusive development. First, the study highlights the importance of inclusive energy policies. Expanding electricity access, especially to underserved and marginalized populations, can play a critical role in reducing income disparities. Policies aimed at universal electrification (e.g., India's Saubhagya Scheme; South Africa's Free Basic Electricity Program) and improvements in grid reliability, combined with affordable access for low-income households (e.g., Kenya's Last Mile Connectivity Project), can help ensure that the benefits of energy access are broadly shared. Importantly, energy policies should focus not only on infrastructure expansion but also on affordability and the quality of access to avoid excluding poorer households.

Second, the strong inequality-reducing effect of social contributions as a share of government revenue underscores the role of robust social protection and social insurance systems in mitigating income inequality. Expansion of contributory and non-contributory social protection (including pensions and conditional cash transfers) helps reduce inequality during periods of economic volatility. For example, Brazil's Bolsa Família and Mexico's Prospera reduce inequality by giving income support tied to education and health. Policymakers should complement growth-oriented policies with targeted interventions in education, health, skill development, and employment generation to prevent growth-induced increases in inequality. The findings regarding India further underscore the importance of policy flexibility and countercyclical social protection measures, particularly during post-crisis recovery phases. Free food grain distribution (PMGKAY) reduced effective consumption inequality by protecting the real incomes of the poorest households.

Overall, energy policy should be viewed not merely as an infrastructure or environmental issue, but as a critical component of broader agendas aimed at reducing inequality and promoting human development. Strengthening social contributions and ensuring universal, affordable access to energy can significantly enhance the distributive impact of economic development.

Conclusion

This study empirically examined the relationship between electricity access and income inequality (measured by the Gini Index) using cross-country data for 24 countries. Ordinary Least Squares estimation reveals that access to electricity, measured as the proportion of the population with access to electricity, and social contributions as a percentage of government revenue are significant determinants of income inequality, in addition to GDP per capita.

While the cross-sectional design limits causal inference, the findings provide clear evidence that electricity access and the fiscal capacity to finance social protection are quantitatively important correlates of income inequality. Future research can build on this study by incorporating additional energy-related indicators, such as access to clean fuels and technologies, as well as renewable energy consumption. Moreover, employing panel data and dynamic econometric specifications would allow for a more accurate assessment of the long-term distributional effects of energy access and social protection policies.

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Statements and Declarations

The study uses secondary data sources. No study or survey was conducted involving human or animal participants directly. Therefore, no ethical approval is required for conducting this study.

Declaration of conflicting interest

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

References

Acheampong, Alex O., Michael Odei Erdiaw-Kwasie, and Matthew Abunyewah. 2021. "Does Energy Accessibility Improve Human Development? Evidence from Energy-Poor Regions." *Energy Economics* 96: 105165. https://doi.org/10.1016/j.eneco.2021.105165

Alvaredo, Facundo; Lucas Chancel; Thomas Piketty; Emmanuel Saez; and Gabriel Zucman. 2018. *World Inequality Report 2018*. Cambridge, MA: Belknap Press. https://wir2018.wid.world/

Bezerra, Paula Borges da Silveira; Camila Ludovique Callegari; Aline Ribas; André F. P. Lucena; Joana Portugal-Pereira; Alexandre Koberle; Alexandre Szklo; and Roberto Schaeffer. 2017. "The Power of Light: Socio-Economic and Environmental Implications of a Rural Electrification Program in Brazil." *Environmental Research Letters* 12, no. 9: 095004. https://doi.org/10.1088/1748-9326/aa7bdd

Biswas, S., Echevarria, A., and Irshad, N. 2022. "Ending the Energy-Poverty Nexus: An Ethical Imperative for Just Transitions." *Science and Engineering Ethics* 28: 36. https://doi.org/10.1007/s11948-022-00383-4

Bourguignon, François. 2015. "Revisiting the Debate on Inequality and Economic Development." *Revue d'économie politique* 125, no. 5: 633–663. https://doi.org/10.3917/redp.255.0633

Chancel, Lucas; Rafael Gómez-Carrera; Rishabh Moshrif; and Thomas Piketty. 2026. *World Inequality Report 2026.* Paris: World Inequality Lab. https://wir2026.wid.world/

Chen, Qingjuan, Chengzhen Xu, and Qunwei Wang. 2025. "Revealing Energy-Economic Inequality in China: A Quantification and Decomposition Analysis." *Sustainable Production and Consumption* 60: 200–216. https://doi.org/10.1016/j.spc.2025.10.002

Churchill, Sefa Awaworyi, and Russell Smyth. 2021. "Energy Poverty and Health: Panel Data Evidence from Australia." *Energy Economics* 97: 105219. https://doi.org/10.1016/j.eneco.2021.105219

Cieslik, Katarzyna. 2016. "Moral Economy Meets Social Enterprise: Community-Based Green Energy Project in Rural Burundi." *World Development* 83: 12–26. https://doi.org/10.1016/j.worlddev.2016.03.009

Department of Economic and Social Affairs. 2025. *Highlights 2025: Towards Sustainable Development for All.* New York: United Nations. https://www.un.org/en/desa/highlights-report-2025

Dugoua, Eugenie, Ruinan Liu, and Johannes Urpelainen. 2017. "Geographic and Socio-Economic Barriers to Rural Electrification: New Evidence from Indian Villages." *Energy Policy* 106: 278–287. https://doi.org/10.1016/j.enpol.2017.03.048

Falchetta, Giacomo. 2021. "Energy Access Investment, Agricultural Profitability, and Rural Development: Time for an Integrated Approach." *Environmental Research: Infrastructure and Sustainability* 1, no. 3: 033002. https://doi.org/10.1088/2634-4505/ac3017

Galbraith, John Kenneth. 1958. *The Affluent Society.* Boston: Houghton Mifflin.

Ghosh, A. 2025. "Decoding Energy Poverty: Rural–Urban Disparities and Structural Barriers in BRICS Countries." *Frontiers in Environmental Economics* 4. https://doi.org/10.3389/frevc.2025.1552502

Hardi, I., Kurniawan, R., Ray, S., Idroes, G. M., Noviandy, T. R., and Majid, M. S. A. 2025. "Reducing the Poverty Gap and Severity in Indonesia: The Role of Renewable Energy Access and Consumption." *Human Settlements and Sustainability* 1, no. 3: 145–157. https://doi.org/10.1016/j.hssust.2025.06.001

International Energy Agency. 2025. *World Energy Outlook 2025.* Paris: IEA. https://www.iea.org/reports/world-energy-outlook-2025

López, L. M. 2025. "Energy Inequalities in Central America: Challenges and Policy Responses." In *Energy Poverty, Justice and Gender in Latin America*, 75–87. Springer. https://doi.org/10.1007/978-3-031-80068-9_3

Ma, Juan, and Henri Njangang. 2025. "The Effect of Gender Inequality in Internet Access on Energy Poverty: A Preliminary Investigation in Developing Countries." *Telecommunications Policy* 49, no. 6: 102959. https://doi.org/10.1016/j.telpol.2025.102959

Mekonnen, Y., and Sarwat, A. I. 2017. "Renewable Energy Supported Microgrid in Rural Electrification of Sub-Saharan Africa." In *2017 IEEE PES PowerAfrica*, 595–599. Accra, Ghana: IEEE. https://doi.org/10.1109/PowerAfrica.2017.7991293

Njiru, Christine W., and Sammy C. Letema. 2018. "Energy Poverty and Its Implication on Standard of Living in Kirinyaga, Kenya." *Journal of Energy*. https://doi.org/10.1155/2018/3196567

Opoku, E. E. O., Acheampong, A. O., and Salim, R. 2025. "Does Energy Access Matter for Achieving Inclusive Growth? Insight from a Global Perspective." *Applied Economics*, 1–18. https://doi.org/10.1080/00036846.2025.2503490

Oum, Sothea. 2019. "Energy Poverty in the Lao PDR and Its Impacts on Education and Health." *Energy Policy* 132: 247–253. https://doi.org/10.1016/j.enpol.2019.05.030

Owolabi, O. A., Omeire, M. C., Okwudire, B. O., and Bolujoko, O. T. 2024. "Education, Electricity Access, and Income Inequality in Nigeria." *International Journal of Energy Economics and Policy* 14, no. 5: 149–161. https://doi.org/10.32479/ijeep.16868

Pang, Qinghua, Xuan Liu, Lina Zhang, and Yung-ho Chiu. 2024. "Temporal-Spatial Evolution of Environmental Inequality of Embodied Energy Transfer within Inter-Provincial Trade of China." *Energy* 299: 131476. https://doi.org/10.1016/j.energy.2024.131476

Sainati, Tristano, Giorgio Locatelli, and Benito Mignacca. 2023. "Social Sustainability of Energy Infrastructures: The Role of the Programme Governance Framework." *Energy* 282: 128630. https://doi.org/10.1016/j.energy.2023.128630

Sambodo, Maxensius Tri, and Rio Novandra. 2019. "The State of Energy Poverty in Indonesia and Its Impact on Welfare." *Energy Policy* 132: 113–121. https://doi.org/10.1016/j.enpol.2019.05.029

Sarkodie, Samuel Asumadu, and Samuel Adams. 2020. "Electricity Access, Human Development Index, Governance and Income Inequality in Sub-Saharan Africa." *Energy Reports* 6: 455–466. https://doi.org/10.1016/j.egyr.2020.02.009

Sen, Amartya. 1980. "Equality of What?" In *Tanner Lectures on Human Values*, Volume 1. Cambridge: Cambridge University Press.

Sen, A. (1988). *The standard of living*. Cambridge University Press.

Song, Yan, Jian Gao, and Ming Zhang. 2023. "Study on the Impact of Energy Poverty on Income Inequality at Different Stages of Economic Development: Evidence from 77 Countries around the World." *Energy* 282: 128816. https://doi.org/10.1016/j.energy.2023.128816

Tripathi, S., and Yenneti, K. 2024. "Does Inequality in Urban Population Distribution Lead to Income Inequality? Evidence from India." *Asia-Pacific Journal* *of Regional Science* 8: 787–818. https://doi.org/10.1007/s41685-024-00345-7

United Nations Development Programme. 2018. *UNDP Annual Report 2018*. New York: UNDP. https://www.undp.org/sites/g/files/zskgke326/files/2022-06/2018GC-REDAnnualReport.pdf

World Bank. 2023. *World Development Indicators Database*. Washington, DC: World Bank. https://databank.worldbank.org/ (accessed October 10, 2025).