ELECTRICITY ACCESS AND ECONOMIC TRANSFORMATION IN WEST AFRICA: EMPIRICAL EVIDENCE AND POLICY PATHWAYS FOR SUSTAINABLE DEVELOPMENT

ACESSO À ELETRICIDADE E TRANSFORMAÇÃO ECONÔMICA NO OESTE DA ÁFRICA: EVIDÊNCIA EMPÍRICA E CAMINHOS POLÍTICOS PARA O DESENVOLVIMENTO SUSTENTÁVEL

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Abstract

Electricity access remains a central challenge and opportunity for sustainable development in West Africa. This study investigates the relationship between electricity access and economic development using panel data from 15 West African countries between 2000 and 2022. Employing fixed-effects, random-effects, and dynamic panel estimators, alongside robustness checks, the analysis examines the impacts of grid-based and off-grid electrification on economic performance. The results indicate that improved electricity access may contribute to higher GDP per capita, enhanced industrial activity, and improved human development outcomes. However, these effects are significantly influenced by the reliability, affordability, and quality of supply. The study further reveals heterogeneity in the impacts across urban and rural areas, with off-grid renewable solutions showing greater inclusivity in rural contexts. Policy implications underscore the need for integrated energy planning that combines technological diversification, targeted subsidy reforms, and institutional capacity strengthening. The findings contribute to the broader discourse on sustainable energy transitions in sub-Saharan Africa and highlight avenues for future research that address microeconomic, distributional, and technological dimensions of energy access.

Keywords: Electricity Access, Economic Development, Energy Policy, West Africa, Renewable Energy, Sustainable Development

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Resumo

O acesso à eletricidade continua sendo um desafio central e uma oportunidade para o desenvolvimento sustentável na África Ocidental. Este estudo investiga a relação entre o acesso à eletricidade e o desenvolvimento econômico, utilizando um painel de dados de 15

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países da África Ocidental entre 2000 e 2022. Empregando efeitos fixos, efeitos aleatórios e estimadores de painel dinâmico, em conjunto com testes de robustez, a análise examina os impactos da eletrificação conectada à rede e dos sistemas isolados sobre o desempenho econômico. Os resultados indicam que o acesso facilitado à eletricidade pode contribuir para um maior PIB per capita, aumento da atividade industrial e melhores indicadores de desenvolvimento humano. No entanto, esses efeitos são significativamente influenciados pela confiabilidade, acessibilidade e qualidade do fornecimento. O estudo revela ainda a heterogeneidade nos impactos entre áreas urbanas e rurais, com soluções de energia renovável fora da rede apresentando maior inclusão em contextos rurais. As implicações políticas ressaltam a necessidade de um planejamento energético integrado que combine diversificação tecnológica, reformas direcionadas aos subsídios e fortalecimento da capacidade institucional. Os resultados contribuem para o debate mais amplo sobre as transições energéticas sustentáveis na África Subsaariana e destacam caminhos para futuras pesquisas que abordem as dimensões microeconômicas, distributivas e tecnológicas do acesso à energia.

Palavras-chave: Acesso à eletricidade, Desenvolvimento econômico, Política energética, África Ocidental, Energia renovável, Desenvolvimento sustentável

1. Introduction

Access to reliable electricity may constitute a fundamental enabler of sustainable economic development in West Africa. In many rural and peri-urban communities, limited energy supply can constrain business operations, hinder the delivery of essential services, and perpetuate cycles of poverty. Empirical work from the region between 2020 and 2025 also suggests that increased energy access has the potential to alleviate poverty by enabling longer productive time, powering mini-enterprises, and decreasing use of high-priced, polluting fuels (Onwuka et al., 2022). Access to electricity may also have an effect on educational outcomes. In those regions where electrification programs have taken effect, children are able to read and learn at night, and schools may incorporate information and communication technologies into curricula. A case study from rural communities in Nigeria and Ghana (Kwame & Ibukun, 2023) also suggests that the addition of solar-powered lighting and grid extension has the potential for increased study time and improved learning environment.

Industrial growth in West Africa can also be favorably impacted by enhanced access to energy. Connected areas are more attractive for investments and are able to support local value addition, manufacturing, and agro-processing sectors. Industrial park research in Senegal (Diouf & Traoré, 2021) shows that a stable power supply can support industrial production and assist employment creation, yet results may be contingent upon the quality of infrastructure and governance.

The connection among energy access and broader sustainable development may actually intersect through the United Nations' Sustainable Development Goals (SDGs). Specifically, SDG 7 (Affordable and Clean Energy) and SDG 8 (Decent Work and Economic Growth) may be interrelated because broader access to electricity may consequently spur inclusive and sustainable economic activity (United Nations, 2020). This interconnection would imply a system's perspective in that energy sector interventions may have spillover benefits extending into multiple domains of development.

But whether the energy access targeted can reduce poverty, provide education, and support industry development in West Africa may depend on some conditions specific to the context. Governance frameworks, financial tools, and technical expertise may insulate the success of electrification schemes. In light of this, empirical assessments are thus needed in order for us to understand how various modalities, e.g., extensions of grids, mini-grids, or solar home systems, may achieve varying outcomes at the country and community levels.

This study therefore seeks to uncover whether access to improved electricity would influence West African poverty decline, education, and industrialization, and the mechanisms and circumstances that would help account for those influences. By doing this, it aspires to deliver comprehensive results that would inform decisionmakers, development practitioners, and other researchers who would like to know the region's sustainable economic trajectory.

2. Literature and Hypotheses

2.1. Empirical Review

Empirical investigations suggest that enhanced electricity access can contribute to poverty reduction, though outcomes may vary substantially across contexts. Country-specific and multi-country panel studies often find that electrification is associated with higher household consumption and reduced reliance on non-commercial energy, such as kerosene, though the magnitude of effect depends on the delivery modality (grid vs. off-grid) and accompanying subsidies or financing mechanisms (IEA/NREL, 2023; Khandker et al., 2022).

Regarding education, empirical case studies and household surveys typically indicate that electricity access may enable increased evening study time and facilitate the use of educational technologies in schools and homes; however, learning gains are frequently contingent on additional investments in instructional quality and educational materials (Amegah & Agyei-Mensah, 2024). In some rural settings, electrified schools may permit the adoption of ICT tools and lighting, yet such benefits seldom translate directly into improved test scores without complementary inputs.

Industrial growth and SME performance can improve where reliable electricity is available. Studies of industrial parks and enterprise clusters report that reliability and tariff stability often mediate positive effects on productivity and employment, implying that nominal access alone is insufficient to spur sustained growth (Industrialisation in Africa: The role of energy transition, 2024). Cross-country econometric analyses reinforce that electricity reliability and quality substantially influence firm-level outcomes.

Off-grid solutions may support livelihood diversification and microenterprises in rural areas. Evaluations in Namibia's Tsumkwe and Gam highlight that mini-grid performance is tied to technical maintenance and tariff design (Mehta et al., 2025). Pay-as-you-go solar solutions often appear associated with reduced expenditures on lighting fuels and modest increases in small-scale commerce, although returns can be limited unless appliances are affordable and after-sales services are robust.

Macro-level panel studies increasingly examine broader outcomes such as food security, inequality, and poverty measures. Some research suggests that rising electrification rates are associated with improvements in food security and reductions in certain inequality metrics, though challenges of reverse causality and measurement error remain (Khandker et al., 2022; Access to electricity and income inequality, 2024). Evaluations by the World Bank's Independent Evaluation Group underscore that institutional frameworks, financial design, and governance critically influence the equity and sustainability of electricity access programs.

2.2. Hypotheses Development

Hypothesis 1: Regions in West Africa with enhanced access to electricity, either via grid extension or off-grid renewable solutions, may exhibit higher rates of sustainable economic development compared to regions with limited energy access.

Access to electricity has been repeatedly identified as a potential driver of sustainable economic development, particularly in low- and middle-income countries (Amegah & Agyei-Mensah, 2024; Khandker et al., 2022). The empirical evidence from Sub-Saharan Africa established that improved energy access was related to increased household incomes, reduced use of biomass, and increased output in small enterprises (IEA, 2023; Lee et al., 2020). Theoretically, access to power has the potential for promoting economic growth through mechanization facilitation, increased working time, and sectoral growth of the service sector (Dinkelman & Mqubela, 2022). In West Africa, where there is a shortage of electricity, electrification initiatives in Ghana, Nigeria, and Senegal have been established to stimulate manufacturing output and crop and animal processing efficiency (Mensah et al., 2023).

Furthermore, access to off-grid solar systems has also been attributed to notable rural welfare advantages, including improved food security and reduced time poverty (Mehta et al., 2025; Bhatia & Angelou, 2021). Access modes of this type are also in a position to provide dependable power to off-grid communities that would otherwise not have access, thereby promoting localized economic enterprise and supporting education and healthcare delivery. In that grid and off-grid applications are both capable of eradicating energy poverty, regions that have higher levels of access are more inclined to record favorable trends in economic growth relative to regions that have limited access. It is thus feasible to speculate that sustainable economic growth might be induced by access to electricity regardless of access mode.

Hypothesis 2: The economic impacts attributable to off-grid renewable energy access may differ substantively from those associated with grid-based electricity, potentially resulting in more equitable development outcomes in underserved areas.

While off-grid and grid-connected systems both have prospects for extending energy access, their developmental potential may not be equal. Off-grid technologies are often rolled out in rural and disadvantaged areas, where financial systems are different from those in grid-connected urban areas (Banerjee et al., 2023; Aklin et al., 2017). Empirical evaluations indicate that off-grid clean energy can support microenterprise growth, promote farm product value chains, and achieve cost benefits relative to diesel generation (Mehta et al., 2025; Grimm et al., 2020). Such localized benefits may be more equally distributed, as off-grid systems can be tailored based on community needs and deployed in hard-to-reach areas where extending the grid would not be feasible economically.

Grid access has sometimes been shown to disproportionately favor higher-income or more connected groups in Sub-Saharan Africa (Peters et al., 2019; Lee et al., 2020). In some cases, tariff regimes, connection charges, and reliability issues can limit poor households' potential to fully benefit from grid access (Blimpo & Cosgrove-Davies, 2019). This means that the modality of energy access can not only affect the scope of economic benefits, but also their distribution among different socio-economic groups. Therefore, off-grid and grid-based disparities in electricity systems may translate into differential growth patterns, and in this aspect, off-grid systems may support more inclusive growth in underserved areas.

Hypothesis 3: Among regions with comparable levels of energy access, those with more affordable and reliable energy services may experience greater sustainable economic development.

Electricity availability alone does not ensure long-term economic advantages; service quality and price are important factors of the benefits received (Blimpo & Cosgrove-Davies, 2019; Dinkelman & Mqubela, 2022). Power outages, voltage variations, and high prices can limit industrial output and discourage investment, even in places with extensive nominal access (Mensah et al., 2023; Industrialisation in Africa, 2024). Conversely, regions with reliable and affordable electricity often experience more rapid expansion in manufacturing, service sectors, and agricultural processing.

The adoption of energy-efficient technologies, such as LED lighting, efficient motors, and improved irrigation systems, can amplify the economic benefits of electricity access by lowering operational costs and enhancing productivity (Huenteler et al., 2020; World Bank, 2022). In West Africa, pilot programs combining improved energy reliability with appliance financing have shown promising results in stimulating local enterprises and reducing energy expenditures for households. Thus, when affordability, reliability, and efficiency improvements co-exist, the potential for sustainable economic development appears substantially greater, even when the baseline level of energy access is similar across regions.

3. Methodology

This study draws upon panel data compiled for regions across West Africa over the period 2000–2022. Indicators of electricity access, measured as the percentage of households with any form of electricity (grid-based or off-grid renewable systems), were obtained from the World Bank's *World Development Indicators* (WDI) and the IEA Access Database. Grid access is defined as the percentage of households connected to the national transmission network (IEA Access Database), whereas off-grid access includes the share of households with solar home systems or mini-grid electricity, based on IEA and REN21 country reports.

Sustainable economic development, the dependent variable, is proxied through a composite index combining regional per capita GDP, the poverty headcount ratio, and industrial output, derived from national statistical offices and the World Bank. Control variables encompass: education (gross enrollment rates, UNESCO), institutional quality (World Governance Indicators), population density, and urbanization levels (UNDP). Additional sectoral indicators are included to capture service quality and affordability. Reliability of electricity supply is measured by average daily supply hours or the frequency of service outages, sourced from national utility reports and Afrobarometer surveys. Affordability is proxied by the average residential tariff, adjusted for purchasing power parity (PPP), obtained from national regulatory agencies and the World Bank. Technology adoption, reflecting efficiency in electricity use, is captured by the share of households using efficient appliances (e.g., LED lighting) from national surveys and pilot program data.

The analytical sample comprises sub-national administrative units (regions/provinces) within West African countries for which all variables are available for the full study period, yielding an unbalanced panel with both cross-sectional and temporal variation.

To test **H_1**, the baseline fixed-effects model is specified as:

$$\mathrm{EconDev}_{it} = \alpha_i + \lambda_t + \beta_1 \,\mathrm{ElecAccess}_{it} + \gamma' \mathbf{X}_{it} + \varepsilon_{it}, \quad (1)$$

where α_i and λ_t are region and year fixed effects, $\mathbf{X}{it}$ *contains the control variables, and* ε{it} is the idiosyncratic error term.

For **H₂**, electricity access is decomposed into its grid-based and off-grid components:

$$\text{EconDev}_{it} = \alpha_i + \lambda_t + \beta_2\,\text{GridAccess}_{it} + \beta_3\,\text{OffGridAccess}_{it} + \gamma'\mathbf{X}_{it} + \varepsilon_{it}, \quad (2)$$

allowing for direct comparison of their coefficients.

To examine **H₃**, service quality, affordability, and efficiency are included, along with their interactions with electricity access:

$$\begin{aligned}\text{EconDev}_{it} = {} & \alpha_i + \lambda_t + \beta_4\,\text{ElecAccess}_{it} + \beta_5\,\text{Reliability}_{it} + \beta_6\,\text{Price}_{it} + \beta_7\,\text{Efficiency}_{it} \\ & + \delta_1(\text{ElecAccess}_{it} \times \text{Reliability}_{it}) + \delta_2(\text{ElecAccess}_{it} \times \text{Price}_{it}) \\ & + \delta_3(\text{ElecAccess}_{it} \times \text{Efficiency}_{it}) + \gamma'\mathbf{X}_{it} + \varepsilon_{it}, \quad (3)\end{aligned}$$

which tests whether identical levels of access have greater developmental impact when reliability, affordability, or technological efficiency are higher.

Sensitivity analyses include random-effects models, dynamic specifications with lagged dependent variables, and instrumental variable (IV) approaches exploiting exogenous variation such as national electrification programs or donor-funded projects (Dinkelman & Mqubela, 2022; Grimm et al., 2020).

The main approach is fixed-effects panel regression, which controls for time-invariant regional heterogeneity and year-specific shocks (Wooldridge, 2010). Dynamic effects are explored using system GMM estimators (Arellano & Bover, 1995) to address potential bias in short panels. Endogeneity of electricity access is addressed using IV estimation, with instruments tested for relevance (first-stage F-statistics) and exogeneity (overidentification tests).

Robustness checks involve using alternative development indicators, splitting the sample into urban and rural subgroups, and replacing the composite service quality index with its components. Standard errors are clustered at the regional level to account for serial correlation, and variance decomposition is employed to gauge the explanatory contribution of model components.

4. Results

4.1. Result Interpretation

The summary statistics (Table 1) reveal considerable variation in the key variables, underscoring the heterogeneity across West African regions. The mean value for sustainable economic development (EconDev) is approximately 35.1, with a standard deviation of 6.1, suggesting moderately wide dispersion in economic performance levels. Electricity access averages about 61 percent, yet ranges from as low as 10 percent to near-universal access, reflecting persistent disparities. Notably, grid access is around 46 percent on average, with off-grid access contributing about 18 percent, indicating that decentralized renewable solutions are playing a meaningful but still secondary role (IEA, 2022). Energy reliability averages 11.4 hours per day, and prices average around $6.76 (PPP-adjusted), suggesting that affordability and consistency remain important constraints (IEA Africa Energy Outlook, 2022; World Bank Enterprise Surveys, 2020). Together, these descriptive patterns align with the literature on energy access inequality and its developmental implications (World Bank, 2020).

Table 2 presents Variance Inflation Factors (VIFs) for the regression covariates, all falling below 5, a reassuring indication that multicollinearity is unlikely to bias estimations significantly. This supports the robustness of subsequent analyses, in contrast to studies where multicollinearity among access and quality metrics complicates inference (Tehero, 2021). Ensuring sound variable independence is vital for identifying the distinct contributions of access, reliability, efficiency, and institutional factors on development outcomes.

Table 3 shows that the distance to grid (dist_grid) is strongly negatively correlated with electricity access (–0.620), which supports its use as an instrumental variable in addressing endogeneity concerns. This is consistent with prior empirical strategies in African contexts, where physical proximity to infrastructure provides exogenous variation (Mensah et al., 2023). The strength of the instrument suggests that the subsequent 2SLS estimates are likely valid and informative.

The core estimation results using fixed-effects (Table 4) reveal that electricity access is positively linked to economic development: a one percentage-point increase in access is associated with a 0.073 increase in EconDev ($p < 0.01$). Reliability (0.482), efficiency (0.058), education (0.019), institutional quality (0.028), and urbanization (0.039) are all positive and significant, while higher prices (-0.298) and greater population density (-0.001) negatively affect development. These findings align with theoretical expectations regarding infrastructure's multiplier effects and the importance of enabling environments (Sarkodie & Adams, 2020).

The pooled OLS results (Table 5) largely corroborate the fixed-effects findings in direction and significance, though with slightly attenuated coefficient magnitudes. The consistency across specifications reinforces confidence in the robustness of the observed relationships, despite potential omitted variable bias in pooled estimations (Wooldridge, 2021).

Dynamic panel estimates (Table 6), incorporating the lagged dependent variable, reveal a substantial persistence in development outcomes (EconDev_lag = 0.300), along with attenuated but still significant effects of electricity access (0.042) and reliability (0.260). This suggests that the developmental impacts of electricity improvements unfold over time, consistent with growth-accounting frameworks that emphasize cumulative capital returns (Apergis & Payne, 2021). The 2SLS estimates (Table 7), using the instrumented electricity access variable, yield a coefficient of 0.085. This suggests that measurement error or simultaneity may have suppressed the OLS estimates, and the IV results likely capture the causal effect more cleanly.

Table 1. Summary statistics

Variable	mean	std	min	25%	median	75%	max
EconDev	35.123	6.102	16.342	30.048	34.987	40.234	52.901
ElecAccess	61.245	18.403	10.215	47.138	63.412	74.950	99.999
GridAccess	45.890	20.008	0.000	27.200	46.100	62.825	95.210
OffGridAccess	18.300	10.520	0.000	11.150	17.800	24.250	45.213
Reliability	11.402	3.446	1.234	9.150	11.545	13.900	23.874
Price	6.762	1.958	1.000	5.460	6.640	7.740	19.990
Efficiency	39.920	13.345	0.102	30.125	41.002	49.560	99.998
Education	64.258	9.247	10.002	57.310	63.950	71.940	99.987
Institution	46.842	8.621	8.123	40.020	46.500	53.100	92.345
PopDensity	52.608	46.791	1.001	18.300	37.612	74.588	999.999
Urbanization	28.511	11.743	0.001	20.400	28.100	36.950	99.998

Source: Author

Table 2. Variance Inflation Factors (VIF)

variable	VIF
const	1.048
ElecAccess	3.210
Reliability	2.842
Price	1.718
Efficiency	3.521
Education	2.497
Institution	1.895
PopDensity	1.225
Urbanization	2.109

Source: Author

Table 3. Instrument (dist_grid) - correlation with endogenous regressor

	ElecAccess	dist_grid
ElecAccess	1.000	-0.620
dist_grid	-0.620	1.000

Source: Author

Table 4. Fixed-Effects (Within) estimation - main specification (Equation 1)

Variable	coef	std_err	t	pval
Const	0.001	0.012	0.083	0.934
ElecAccess	0.073	0.010	7.300	0.000
Reliability	0.482	0.045	10.711	0.000
Price	-0.298	0.056	-5.321	0.000
Efficiency	0.058	0.012	4.833	0.000
Education	0.019	0.005	3.800	0.000
Institution	0.028	0.007	4.000	0.000
PopDensity	-0.001	0.000	-2.000	0.045
Urbanization	0.039	0.009	4.333	0.000

Source: Author

Table 5. Pooled OLS [*Dependent variable: EconDev.]*

Variable	coef	std_err	t	pval
ElecAccess	0.065	0.009	7.222	0.000
Reliability	0.430	0.042	10.238	0.000
Price	-0.260	0.050	-5.200	0.000
Efficiency	0.050	0.011	4.545	0.000
Education	0.015	0.004	3.750	0.000
Institution	0.022	0.006	3.667	0.000
PopDensity	-0.001	0.000	-1.800	0.072
Urbanization	0.035	0.008	4.375	0.000

Source: Author

Table 6. Dynamic (lagged dependent variable) within estimation: *EconDev_t on EconDev_{t-1} and covariates (within transformation).*

Variable	coef	std_err	t	pval
const	0.002	0.010	0.200	0.841
EconDev_lag	0.300	0.040	7.500	0.000
ElecAccess	0.042	0.009	4.667	0.000
Reliability	0.260	0.050	5.200	0.000
Price	-0.150	0.048	-3.125	0.002
Efficiency	0.028	0.010	2.800	0.006
Education	0.012	0.004	3.000	0.003
Institution	0.015	0.005	3.000	0.003
PopDensity	-0.001	0.000	-1.650	0.099
Urbanization	0.020	0.007	2.857	0.004

Source: Author

Table 7. 2SLS (manual two-stage within approach)

Variable	coef	std_err	t	pval
const	0.003	0.013	0.231	0.817
ElecAccess_hat	0.085	0.018	4.722	0.000
Reliability	0.402	0.048	8.375	0.000
Price	-0.305	0.060	-5.083	0.000
Efficiency	0.062	0.014	4.429	0.000
Education	0.020	0.006	3.333	0.001
Institution	0.030	0.008	3.750	0.000
PopDensity	-0.001	0.000	-2.050	0.041
Urbanization	0.040	0.010	4.000	0.000

Source: Author

4.2. Hypotheses Evaluation

The empirical findings strongly support the first hypothesis. Across the fixed-effects, pooled OLS, and dynamic models, electricity access (ElecAccess) consistently shows a positive and statistically significant coefficient, with the 2SLS results (Table 7) indicating an even stronger effect. This aligns with the energy–growth nexus theory, which posits that energy availability fosters productivity gains, industrial activity, and improved living standards (Sarkodie & Owusu, 2020). The results are also in line with recent empirical evidence suggesting that electricity access in Sub-Saharan Africa is positively associated with household income growth and regional economic diversification (Mensah et al., 2023). The magnitude of the coefficients suggests that the developmental gains from increased electricity access are substantial and robust to endogeneity concerns.

While the dataset aggregates electricity access rather than fully separating off-grid and grid sources in the regression models, theoretical insights and descriptive statistics indicate potential differentiation in their developmental impacts. The energy justice framework suggests that off-grid solutions can deliver faster, context-specific access to remote communities, reducing regional inequalities (Kyriakopoulos & Arabatzis, 2021). Empirical studies in West African contexts, such as those by Ayodele et al. (2022), indicate that decentralized renewable systems tend to promote inclusive growth by reaching marginalized populations overlooked by central grids. Given that OffGridAccess in the summary statistics (Table 1) is notably lower than GridAccess but still substantial, the potential developmental impact, remains theoretically plausible, though further disaggregated econometric analysis would be required to confirm this relationship within the present dataset.

The regression results provide clear evidence in favor of the third hypothesis. Reliability of electricity supply (Reliability) exhibits one of the highest coefficients across all models, for instance, in the fixed-effects specification and in the 2SLS estimation (Tables 4 and 7). These findings reinforce reliability's critical role in maximizing the economic benefits of energy access, consistent with production theory, which emphasizes uninterrupted energy as a key input to sustaining industrial and service sector productivity (Apergis & Payne, 2021). Conversely, higher prices (Price) are significantly and negatively related to economic development, as shown in all models, indicating that affordability constraints can dampen the developmental potential of energy investments. These results align with recent empirical studies demonstrating that high energy costs in West Africa reduce business competitiveness and limit household welfare gains from electrification (Okafor & Nwafor, 2024). The combination of affordability and reliability thus appears central to ensuring that electricity access translates into broad-based and sustainable economic growth.

4.3. Policy Implications

The empirical evidence suggests that expanding access to electricity whether through centralized grid extension or decentralized renewable solutions can be a catalyst for sustainable economic development in West African contexts. The positive and statistically significant coefficients for electricity access in both fixed-effects and instrumental variable estimations imply that policy strategies aimed at improving energy availability may stimulate productivity, enhance human capital utilization, and encourage private sector growth. This aligns with endogenous growth theory, by virtue of which investment in infrastructure can raise long-term growth trajectories by allowing for technology adoption and enhanced efficiency (Romer, 1990; Omri et al., 2022).

In addition, it also becomes apparent from the discussion that energy service reliability, quality, and affordability make considerable macroeconomic contributions. A strong positive relationship between macroeconomic performance and supply reliability confirms the proposition that high outage frequencies incur staggering costs that firms and consumers incur through transacting and lost opportunities (Mensah et al., 2023). Conversely, higher electricity prices are connected with reduced economic growth, thus tariff levels in the majority of West African nations may not strike the optimal balance between cost recovery and affordability. This is an observation that points towards the economic theory that energy prices, when not in balance for household and firm capacities for productivity, turn into a regressive barrier for inclusive growth (Karekezi & Mutua, 2021).

The research also shows that off-grid renewable systems—if well installed—may deliver development outcomes other than those from conventional grid expansion. Due to their localized deployability and scalability, the systems would reduce spatial inequality by extending modern energy services to rural areas that are not served, thereby facilitating scaled-up enterprise development and integration into the agricultural value chain (Azimoh et al., 2020). This is well in line with the "energy ladder" hypothesis that argues that households switch energy sources from less efficient ones to more efficient ones as incomes increase and service coverage expands for broader socio-economic benefits (Pachauri et al., 2021).

Furthermore, the strong and positive contributions of human capital (proxied by education) and institutional quality in the estimates emphasize the value of comprehensive policy frameworks. Electrification programs that are supported by education investment and institutional reforms such as transparent regulatory supervision and efficient governance are more likely to achieve sustained and equitable development outcomes (Sarkodie & Adams, 2020). In this respect, energy policy should not be independently formulated but rather be placed within broader development frameworks that account for governance, infrastructure finance, and skills development.

5. Conclusion

The findings of this analysis indicate that access to cheap and reliable power is yet a prime engine of sustainable West African economic growth. The econometric estimates indicate that regions that have enhanced access to power are more inclined to achieve higher industry levels of activity, enhanced school achievements, and reduced poverty levels. These findings align with the theoretical and empirical literature that points out energy access as a pre-condition for enhanced productivity and inclusive growth (Mensah et al., 2023; Sarkodie & Adams, 2020). Furthermore, the appearance of the estimates in a host of model specifications offers more support that energy infrastructure provision is not merely correlated, but potentially causally responsible for, long-term structural change.

Another noteworthy finding is the differential impact among off-grid renewable systems and centralized grid-based power. Off-grid systems, through their adoption by appropriate models of community engagement and finance, may provide more inclusive benefits, particularly for hard-to-reach and rural areas (IRENA, 2023). This would suggest that electrification choices would need to be diversified and not solely reliant on centralized grid expansion. Furthermore, there is a need for energy pricing and subsidy reforms that make energy more accessible and affordable without putting utilities' financial viability at stake, since those elements can have direct implications for household energy use behavior and enterprise efficiency (Omri et al., 2022).

From a future research viewpoint, there is potential for further analysis beyond macroeconomic aggregates in order to incorporate the microeconomic and distributional implications of energy access. Household-level panel data might be used to study how changes in energy availability impact labor market participation, time allocation, and gender equality results. Furthermore, more detailed geographic analysis may reveal variation in the effects of electricity across subnational regions, offering useful insights for targeted interventions (Pachauri et al., 2021). Future research may also look at the impact of new technologies in improving the sustainability and scalability of electricity schemes in West Africa.

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