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Energy Consumption, Foreign Direct Investment and Economic Growth: A Narrative Survey of Developing Country Evidence

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Abstract

The relationship between energy consumption, foreign direct investment (FDI) and economic growth in developing economies has generated a large but fragmented empirical literature, with findings that diverge across countries, energy types, and methodological approaches. This survey narrates evidence through a three-dimensional framework that organizes the literature by regulatory stringency, renewable-versus-non-renewable FDI composition, and econometric strength, benchmarked against the four canonical energy-growth hypotheses. The synthesis reveals that the growth hypothesis consistently dominates for non-renewable energy consumption in low-income, energy-importing countries, while the conservation and neutrality hypotheses are more prevalent in middle-income economies with diversified energy mixes. FDI's impact on growth proves conditional on absorptive capacity: in countries with strong regulatory frameworks and human capital, FDI in renewable energy generates a positive feedback loop, whereas in weak-regulation environments the pollution haven effect produces a trade-off of short-run growth gains against long-run environmental costs. Methodological analysis indicates that the progressive evolution from bivariate Granger-causality to multivariate vector error correction models and nonlinear ARDL has resolved key identification challenges, yet the evidence base for Sub-Saharan Africa remains dominated by single-country studies with limited external validity. The Uganda case, where the electricity sector oscillated between privatization (1999) and re-nationalization (2023), illustrates the critical role of policy stability as a threshold condition for energy-sector FDI to translate into sustainable economic growth.

Keywords: ***Energy consumption, Foreign direct investment, Economic growth, Energy-growth hypothesis, Pollution haven, Vector error correction model, Uganda***

Introduction and Background

The nexus between energy consumption, foreign direct investment (FDI), and economic growth has become one of the most actively debated questions in development economics (Xuan 2025). Energy is widely recognized as a critical input for economic growth, and the energy sector in developing countries is increasingly dominated by FDI (Adom & Amuakwa-Mensah, 2016). The results of the debate have generated dissenting results (Mutumba et al 2021).

Yet the direction of causality among these variables, and the conditions under which energy sector FDI contributes to sustainable growth rather than environmental degradation, remain contested. This narrative survey addresses that gap by evaluating the energy-growth FDI nexus through a three-dimensional policy evidence framework that systematically compares energy, FDI composition, and growth, to identify the conditions under which energy-sector FDI contributes to sustainable growth in developing economies. The analytical challenge is substantially larg within empirical literature. It has produced four competing hypotheses about the energy-growth relationship: the growth hypothesis (energy causes growth), the conservation hypothesis (growth causes energy consumption), the feedback hypothesis (bidirectional causality), and the neutrality hypothesis (no causal link) (Emirmahmutoglu et al., 2021). These hypotheses are not merely academic distinctions; they carry direct policy implications. If the growth hypothesis holds, energy conservation policies risk slowing economic expansion. If the conservation hypothesis dominates, energy subsidies may be wasteful. The distribution of empirical support across these hypotheses is shaped by sample composition, energy-type disaggregation, and methodological choices (Akinlo, 2008).

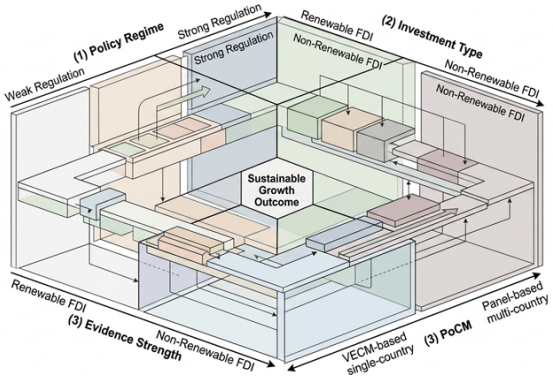
Uganda provides a particularly instructive case for examining this nexus. The country's energy matrix is dominated by biomass (89%), with fossil fuels and electricity contributing only 9% and 2%, respectively (Mutumba et al., 2024b). This composition creates a distinct analytical profile: the

energy-growth relationship for the 11% modern-energy component may differ fundamentally from that of the 89% biomass share, yet the existing literature almost exclusively studies the former. Uganda has also experienced a pronounced policy oscillation in its electricity sector, with the 1999 privatization of the Uganda Electricity Board followed by its 2023 re-nationalization, creating a natural experiment in the relationship between regulatory stability and energy-sector FDI (Mutumba et al., 2025). Furthermore, Uganda's involvement in the East African Community's regional energy-market integration initiative adds a supra-national dimension to the policy analysis.

It contributes to the literature in three ways. First, it provides the first systematic synthesis of the energy-growth-FDI nexus that simultaneously covers all four energy-growth hypotheses, the pollution haven debate, and the full range of methodological approaches from bivariate Granger-causality to nonlinear ARDL. Second, it develops a three-dimensional policy-investment-evidence framework that allows systematic comparison of findings across studies that differ in regulatory context, FDI composition, and identification strategy. Third, it uses Uganda as an anchoring case to illustrate how the general findings of the cross-country literature translate, or fail to translate, to the specific conditions of a low-income, biomass-dependent, energy-importing economy.

The survey's three-dimensional evaluation framework, illustrated in Figure 1, organizes the empirical literature along three axes: policy regime (regulation stringency), investment type (renewable vs. non-renewable FDI), and evidence strength (VECM-based vs. panel-based causality). The framework is benchmarked against the four canonical energy-growth hypotheses, enabling systematic comparison of findings across studies that differ in regulatory context, FDI composition, and identification strategy.

Figure 1: Three-dimensional policy-investment-evidence evaluation framework



The remainder of the narrative survey is organized as follows. Section 2 establishes the theoretical foundations, tracing the evolution from the neoclassical Solow model to endogenous growth frameworks and formally defining the four energy-growth hypotheses. Section 3 synthesizes the empirical evidence on energy-growth causality in developing economies, with particular attention to Sub-Saharan African studies. Section 4 examines the dual role of FDI in the energy sector as both a growth driver and a potential pollution vehicle. Section 5 provides a comparative assessment of the econometric methods employed in the literature. Section 6 translates the evidence into policy implications for Uganda and the East African region. Section 7 identifies research gaps and assesses evidence strength. Section 8 concludes.

Theoretical Foundations of the Energy-Growth Nexus

Energy as a factor of production: from Solow to endogenous growth

The theoretical justification for treating energy as a distinct factor of production traces to the recognition that the neoclassical Solow growth model, with its emphasis on capital and labor as the primary inputs, systematically omits the role of energy in modern economies. Augmenting the neoclassical production function with energy consumption resolves the omitted-variable bias that plagued early single-equation growth regressions. In the standard augmented framework, output is specified as a function of capital, labor, and energy: $Y_t=f(K_t,L_t,E_t)$, where energy consumption enters as a flow variable distinct from the capital stock (Mathur et al., 2016).

The theoretical distinction between energy as a flow resource and capital as a stock has important implications for econometric specification. Capital formation represents accumulated investment that depreciates over time, while energy consumption is a contemporaneous flow that is instantaneously transformed into productive work. This distinction implies that the long-run relationship between energy and growth is mediated by the capital stock: energy enables capital to operate, but capital determines the economy's capacity to absorb energy productively. The endogenous growth literature further complicates this picture by treating technological progress as an outcome of investment decisions, including investments in energy efficiency and renewable energy infrastructure (Shahbaz et al., 2013).

The multivariate framework that dominates contemporary empirical work includes not only energy and capital but also FDI, labor, and sometimes financial development, trade openness, and carbon emissions. This expansion reflects the recognition that energy consumption does not operate in isolation: FDI may simultaneously affect energy demand (by building energy infrastructure), energy supply (by importing energy-intensive production technologies), and growth (through capital formation and technology transfer). The theoretical challenge is to disentangle these channels, which requires careful attention to the direction of causality and the choice of identifying assumptions (Menegaki & Tugcu, 2016).

The four hypotheses: growth, conservation, feedback, and neutrality

The four competing energy-growth hypotheses including growth, conservation, feedback, and neutrality. It represent a progressive theoretical decomposition: the growth hypothesis requires energy to be a binding constraint on output (A), the conservation hypothesis inverts this causal direction (B), the feedback hypothesis unifies both (A↔B), and the neutrality hypothesis rejects any causal link, with the choice among them depending critically on whether energy is modeled as a separable flow input or as a capital-complementing factor (Emirmahmutoglu et al., 2021).

The growth hypothesis posits that energy consumption Granger-causes economic growth. Under this hypothesis, energy is a binding constraint: reductions in energy availability directly reduce output, and energy conservation policies carry growth costs. This hypothesis finds its strongest theoretical support in economies where energy infrastructure is underdeveloped and where energy imports constitute a large share of the import bill, as is the case for many Sub-Saharan African countries (Akinlo, 2008).

The conservation hypothesis reverses the causal direction: economic growth Granger-causes energy consumption. This implies that energy conservation policies can be implemented without adverse growth effects, since growth drives energy demand rather than the reverse. The conservation hypothesis is more prevalent in middle-income economies

with diversified energy mixes, where growth can proceed through energy-efficient sectors while energy-intensive sectors contract. The feedback hypothesis recognizes bidirectional causality: energy and growth reinforce each other. This is the most theoretically nuanced hypothesis, as it implies that energy and growth are jointly determined and that policy interventions in either domain will have spillover effects on the other. The neutrality hypothesis, by contrast, rejects any causal link, suggesting that energy and growth are determined by separate processes and that energy policies have no growth consequences. The growth hypothesis dominates in low-income energy-importing countries, while the conservation hypothesis is more prevalent in middle-income economies with diversified energy mixes (Shahbaz et al., 2015).

The empirical distribution of hypothesis support across developing-country samples reveals that sample composition and methodology are key moderators. Single-country time-series studies, particularly those employing VECM, tend to find support for the growth hypothesis, while panel studies that pool heterogeneous countries are more likely to find conservation or neutrality. This pattern reflects genuine heterogeneity in the energy-growth relationship across development stages rather than mere methodological artifacts (Menegaki & Tugcu, 2016). The implication for survey design is that any synthesis must account for both the country context and the methodological approach that produced each finding.

Empirical Evidence on the Energy-Growth Causality in Developing Economies

The empirical energy-growth literature forms a complementary evidence base: VECM-based single-country studies (e.g., Uganda, Nigeria) capture country-specific long-run equilibria and dominate the Sub-Saharan African evidence, ARDL-based panel studies provide cross-country generalizability, and time-varying causality methods reveal that the growth hypothesis strengthens during periods of energy-capacity expansion.

The three methodological strands converge on the finding that energy-type disaggregation (renewable vs. non-renewable) is the single most important moderator of the energy-growth relationship. This section synthesizes the evidence across these three methodological strands.

Single-country VECM evidence from Sub-Saharan Africa

Single-country VECM studies consistently detect a long-run growth-hypothesis relationship for non-renewable energy in Sub-Saharan Africa, while renewable energy consumption shows country-specific neutrality or weak conservation effects.

The Uganda-specific evidence is particularly instructive. Mutumba et al., 2024a examined the relationship between renewable energy consumption and economic growth in Uganda for the period 1982–2018 using VECM and structural VAR within a multivariate framework that included domestic investment and FDI. The Johansen cointegration test confirmed a long-run equilibrium relationship, and the pairwise Granger-causality test supported the neutral hypothesis between renewable energy consumption and economic growth, with a unidirectional relationship running from renewable energy consumption to economic growth rather than the reverse. This finding is consistent with the structural characteristics of Uganda's energy matrix: renewable energy, primarily hydroelectricity, accounts for a small share of total energy consumption, and its growth effects are likely mediated through the electricity-access channel rather than the aggregate energy-consumption channel.

In contrast, Mutumba et al., 2025 found that non-renewable energy consumption in Uganda supports the growth hypothesis in the long run, as shown by the VECM results for the period 1982–2022. The conclusion attributes this relationship to Uganda's dependence on imported fossil fuels, which are a binding constraint on transport, industry, and electricity generation. This asymmetry between renewable and non-renewable energy findings is not unique to Uganda. Akinlo, 2008 examined 11 Sub-Saharan African countries and found that energy consumption Granger-causes economic growth in several countries, but the direction and significance of causality vary substantially across countries, supporting the argument that country-specific institutional and structural factors mediate the energy-growth relationship.

The broader Sub-Saharan African evidence from panel studies reinforces the importance of disaggregation. The electricity consumption-growth nexus in Gulf Cooperation Council countries, as studied by Salahuddin et al. (Salahuddin et al., 2015), reveals that the long-run relationship is sensitive to the inclusion of carbon emissions and financial development as control variables, suggesting that bivariate models may overstate the energy-growth link by omitting relevant covariates. Kweseh (Wesseh & Lin, 2017) examined whether renewable energy can power Eastern African countries' transition to industrialization and urbanization, finding that renewable energy consumption has a positive but modest long-run effect on economic growth, with the magnitude depending on the level of financial development and the quality of energy infrastructure.

Panel evidence: ARDL and time-varying causality approaches

Time-varying causality methods reveal that the energy-growth nexus is not static: the growth hypothesis strengthens during periods of energy-infrastructure investment and weakens when economies diversify away from energy-intensive sectors. The ARDL-based panel evidence provides cross-country generalizability that single-country VECM studies cannot offer. Hongxing et al. (Hongxing et al., 2021) applied PMG-ARDL to 81 Belt and Road Initiative countries and found that economic growth, energy consumption, urbanization, and trade are cointegrated, with long-run causality running from energy consumption to growth in the full sample but with significant heterogeneity across regional sub-samples. This finding echoes the single-country VECM evidence in suggesting that the energy-growth relationship is not uniform across development stages.

The time-varying approach developed by Emirmahmutoglu et al. (Emirmahmutoglu et al., 2021) represents a methodological advance over static Granger-causality tests. Applied to sectoral data from the United States, the time-varying causality test reveals that the relationship between renewable and non-renewable energy consumption and real output has changed substantially over time, with periods of strong growth-hypothesis support coinciding with energy-infrastructure investment cycles and periods of neutrality coinciding with sectoral shifts toward services. While this evidence comes from a developed economy, the methodological insight that the energy-growth nexus is time-varying implications for developing-country studies. Fixed-parameter models estimated over multi-decade samples may average across periods with fundamentally different causal structures, producing misleading summary statistics.

Zhao et al., (2023) examined the energy-growth nexus at national and regional levels in China, finding that economic growth stimulates energy consumption at the national level but that the direction of causality varies across provinces depending on industrial structure and energy intensity. This within-country heterogeneity suggests that even single-country studies may benefit from sub-national disaggregation, particularly in large, economically diverse developing countries. Halilbegović et al., (2023) modeled the nexus of renewable and non-renewable energy

consumption and economic progress in nine Southeastern European countries using panel estimation techniques, finding that renewable energy consumption supports the conservation hypothesis while non-renewable energy supports the growth hypothesis a pattern that mirrors the Uganda-specific findings (Mutumba et al., 2024; Mutumba et al., 2025).

Table 1: Energy-growth hypothesis support across country groups and energy types

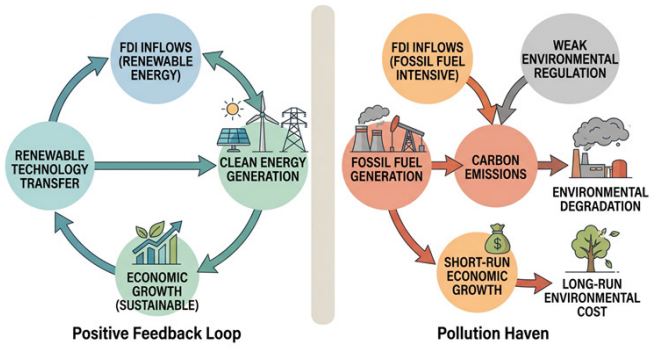
Country group	Renewable energy	Non-renewable energy	Aggregate energy
Low-income SSA	Neutrality / Conservation	Growth	Growth
Middle-income SSA	Conservation	Growth / Feedback	Feedback
Developing Asia	Conservation	Growth	Growth

The pattern that emerges from this evidence is summarized in Table 1. The dominant finding across all country groups is that non-renewable energy consumption supports the growth hypothesis, while renewable energy consumption more frequently supports the conservation or neutrality hypotheses. This asymmetry has important implications for energy policy in developing countries. If the growth hypothesis holds for non-renewable energy, policies that restrict fossil fuel consumption without providing adequate renewable alternatives may carry short-run growth costs. At the same time, the evidence that renewable energy does not yet drive growth in most developing countries suggests that the transition to renewable energy must be accompanied by complementary investments in energy infrastructure, storage, and grid integration to achieve growth effects comparable to those of fossil fuels.

Foreign Direct Investment in the Energy Sector: Growth Driver or Pollution Vehicle?

FDI's impact on growth in developing economies follows a complementary logic: in countries with strong regulatory frameworks and human capital, FDI in renewable energy generates a positive feedback loop (FDI → clean energy → growth → more FDI), while in weak-regulation environments the canonical pollution haven case. FDI in fossil-fuel-intensive sectors produces a contrasting trade-off of short-run growth gains against long-run environmental costs. Figure 2 illustrates these two contrasting pathways.

Figure 2: Conditional effects of FDI on growth: strong vs. weak regulatory environments



The pollution haven hypothesis: evidence and counter-evidence

The pollution haven effect is not uniform: it is strongest in low-regulation, resource-extraction sectors and weakest in renewable-energy FDI where technology transfer dominates the emissions effect. The pollution haven hypothesis, originally formulated by Copeland and Taylor, posits that multinational corporations relocate carbon-intensive production to developing countries with weaker environmental regulation, thereby increasing emissions in host countries while reducing them in home countries. Singhania and Saini (Singhania & Saini, 2021) provide a comprehensive empirical assessment of this hypothesis, finding that the evidence is mixed and that the pollution haven effect is contingent on the sectoral composition of FDI, the stringency of host-country environmental regulation, and the measurement of environmental outcomes.

The sectoral composition of FDI is a critical moderator. FDI in extractive industries and heavy manufacturing is more likely to produce pollution haven effects than FDI in services or light manufacturing (Opoku et al., 2019). Ning et al. (Ma et al., 2023) applied a complex network approach to examine how different forms of FDI affect the carbon emissions of multinational enterprises, finding that horizontal FDI (market-seeking) tends to reduce emissions through technology transfer, while vertical FDI (efficiency-seeking) in pollution-intensive sectors increases emissions. This distinction is important for Uganda, where FDI in the energy sector has been concentrated in hydroelectricity generation, a relatively clean activity, but where FDI in manufacturing and extractive industries may carry higher emissions risks.

The evidence from Sub-Saharan Africa suggests that the pollution haven effect is weaker than in other developing regions, partly because the region's FDI inflows are relatively small and concentrated in extractive sectors where emissions are more visible and therefore more likely to attract regulatory attention (Adom & Amuakwa-Mensah, 2016). Adom (Adom & Amuakwa-Mensah, 2016) found that FDI in East Africa has an energy-saving role, reducing energy intensity rather than increasing it, which is inconsistent with the strong form of the pollution haven hypothesis. However, this finding may reflect the composition of FDI in the region — predominantly in services and light manufacturing — rather than the absence of a pollution haven mechanism.

Absorptive capacity and the conditional growth effect of FDI

FDI promotes growth only above a threshold of human capital and institutional quality, below which the capital-inflow effect is offset by rent-seeking and environmental degradation. The concept of absorptive capacity for the host country's ability to absorb and productively deploy foreign capital and technology has emerged as the central moderating variable in the FDI-growth literature. Opoku et al. (Opoku et al., 2019) examined the sectoral transmission channels through which FDI affects growth in Africa using the system GMM estimator, finding that while FDI positively and unconditionally spurs economic growth in the aggregate, the effect is concentrated in the service sector and is conditional on financial development and human capital.

Appiah-Otoo et al. (Appiah-Otoo et al., 2023) explored the moderating role of FDI in the renewable energy and economic growth nexus in West Africa, finding that FDI enhances the growth effect of renewable energy consumption only in countries with above-median institutional quality. This finding is consistent with the broader absorptive-capacity literature: FDI brings not only capital but also technology and management practices, and the ability to absorb these complementary assets depends on the host country's human capital and institutional environment. Nawaz & Rahman, (2023) examined renewable energy consumption in Sub-Saharan Africa and found that the role of FDI is

mediated by human capital, financial development, and institutional quality, with FDI's positive effect on renewable energy deployment concentrated in countries with stronger institutional environments.

The Uganda-specific evidence on FDI's growth effect is limited but suggestive. The privatization of the Uganda Electricity Board in 1999 was intended to attract FDI into the electricity sector, but the subsequent re-nationalization in 2023 suggests that the expected FDI inflows did not materialize at the scale or with the growth effects anticipated. This pattern is consistent with the absorptive-capacity literature: institutional instability and policy uncertainty create a regulatory-uncertainty discount that deters the long-horizon FDI needed for energy-infrastructure investment (Mugume & Bulime, 2024). Mugume & Bulime, 2024 examined how Africa's financial sector can deliver economic growth and renewable energy transition simultaneously, finding that the finance-growth-energy nexus is mediated by regulatory quality and that countries with unstable energy policies fail to attract the scale of FDI needed for renewable energy transition.

The absorptive-capacity framework also helps explain why some countries benefit from FDI in the energy sector while others do not. In countries with strong regulatory frameworks and human capital, FDI in renewable energy generates a positive feedback loop: FDI finances clean energy infrastructure, clean energy reduces the growth-dependence on imported fossil fuels, growth attracts more FDI, and the cycle reinforces itself (Caglar, 2020). In countries with weak regulatory frameworks, by contrast, FDI in fossil-fuel-intensive sectors produces short-run growth gains at the cost of long-run environmental degradation, and the absence of institutional mechanisms for reinvesting FDI rents into clean energy infrastructure means that the growth effect is transient.

Methodological Approaches in the Energy-FDI-Growth Literature

The methodological evolution from bivariate Granger-causality to multivariate VECM and NARDL reflects a progressive refinement: each generation of methods addresses a specific weakness of its predecessor omitted-variable bias (VECM over bivariate), symmetry assumptions (NARDL over linear ARDL), and cross-sectional dependence (panel cointegration over pooled OLS) but the complementary logic among these methods means that no single approach is sufficient; the strongest evidence comes from studies that triangulate across multiple methods.

VECM and Granger causality: specification choices and interpretation
The error-correction term in VECM specifications is the critical bridge between short-run Granger-causality tests and long-run equilibrium relationships, and its omission leads to spurious conservation-hypothesis findings. The standard VECM-Granger workflow proceeds through four stages: unit-root testing, cointegration testing, VECM estimation, and Granger-causality testing. Each stage involves specification choices that can materially affect the conclusions.

The first stage, unit-root testing, determines whether variables are stationary in levels or require first-differencing. The Augmented Dickey-Fuller (ADF) test remains the most common approach, but its low power in small samples is a characteristic of single-country studies with 30–40 annual observations means that the null of a unit root is often not rejected even when the variable is stationary (Mathur et al., 2016).

The second stage, cointegration testing, determines whether a long-run equilibrium relationship exists among the variables. The Johansen cointegration test is the standard for multivariate systems, but its reliability depends on correct lag-length selection and the absence of structural breaks. Mathur et al. (Mathur et al., 2016) demonstrated that panel cointegration tests can yield different conclusions than single-country Johansen tests, with the panel approach finding cointegration in developing-country panels where single-country tests do not, suggesting that the panel approach pools information across countries to increase power.

The third stage, VECM estimation, separates the short-run dynamics from the long-run equilibrium relationship. The error-correction term (ECT) measures the speed of adjustment toward the long-run equilibrium: a significant and negative ECT coefficient indicates that deviations from equilibrium are corrected over time. The ECT is the critical bridge between the cointegration and causality stages.

Shahbaz et al., (2015) applied the ARDL approach to cointegration for Pakistan, finding that renewable energy consumption adds to economic growth in the long run, with the ECT confirming the existence of a long-run equilibrium relationship. The fourth stage, Granger-causality testing, determines the direction of causality. In a VECM framework, causality can operate through two channels: the lagged differences of the independent variables (short-run causality) and the ECT (long-run causality). Omitting the ECT from the causality test a common specification error can produce spurious conservation-hypothesis findings because the long-run adjustment mechanism is ignored.

Panel methods and the challenge of cross-sectional dependence
Second-generation panel estimators that account for cross-sectional dependence systematically weaken the FDI-growth coefficient relative to first-generation estimates, suggesting that some of the reported FDI-growth effects reflect common global shocks rather than causal FDI impacts. The evolution from first-generation panel methods (FMOLS, DOLS) to second-generation approaches (CS-ARDL, AMG) represents a significant methodological advance in the energy-FDI-growth literature. First-generation methods assume cross-sectional independence that the error terms of different countries are uncorrelated. This assumption is implausible in the energy-FDI-growth context, where global energy prices, international capital flows, and common technological shocks affect all countries simultaneously.

Zhao et al., (2023) demonstrated that the energy-growth relationship at the regional level in China differs substantially from the national-level relationship, and that pooling provinces without accounting for cross-sectional dependence produces misleading results. Halilbegović et al., (2023) applied panel estimation techniques to nine Southeastern European countries and found that the choice between first-generation and second-generation estimators affects the magnitude and significance of the energy-growth coefficients. The implications for the FDI-growth literature are particularly important.

Orach et al. (Orach et al., 2024) examined the impact of energy consumption, financial development, and FDI on environmental quality using static and dynamic panel models, finding that the FDI coefficient is sensitive to the choice of estimator and that dynamic models that account for cross-sectional dependence produce smaller and less significant FDI effects than static models.

The methodological implication is that the strongest evidence comes from studies that triangulate across multiple methods. A finding that is robust to the choice between VECM and ARDL, between first-generation and second-generation panel estimators, and between linear and nonlinear specifications carries more weight than a finding that is sensitive to any of these choices. The Uganda-specific evidence is currently limited to VECM-based single-country studies (Mutumba et al., 2024a; Mutumba et al., 2025); the application of time-varying causality, nonlinear ARDL, and panel methods with Uganda-specific subsamples would substantially strengthen the evidence base.

Table 2: Methodological approaches in the energy-FDI-growth literature

Method	Key strength	Key limitation	Representative study
Bivariate Granger	Simple, intuitive	Omitted-variable bias	Akinlo (2008)
VECM	Separates short/long run	Requires large samples	Mutumba et al. (2024b) (Mutumba et al., 2024a)
ARDL	Mixed integration orders	Sensitive to lag selection	Shahbaz et al. (2015) (Shahbaz et al., 2015)
FMOLS/DOLS	Panel cointegration	Assumes cross-sectional independence	Halilbegović et al. (2023) (Halilbegović et al., 2023)
CS-ARDL/AMG	Handles cross-sectional dependence	Requires large N, T	Emirmahmutoglu et al. (2021) (Emirmahmutoglu et al., 2021)
NARDL	Asymmetric effects	Limited to single country	—

Table 2 summarizes the key methodological approaches. The progression from bivariate Granger-causality to multivariate VECM, ARDL, and panel cointegration is not merely a technical refinement; it reflects a deeper evolution in the conceptual understanding of the energy-growth-FDI nexus. Early studies treated energy and growth as a bivariate system, implicitly assuming that no other variables mediated or confounded the relationship. The multivariate turn recognized that capital, labor, FDI, and financial development are simultaneously determined with energy and growth, and that omitting these variables produces biased estimates. The most recent methodological advances — time-varying causality, nonlinear ARDL, and second-generation panel estimators — address the remaining limitations: the assumption of parameter stability over time, the assumption of symmetric effects, and the assumption of cross-sectional independence.

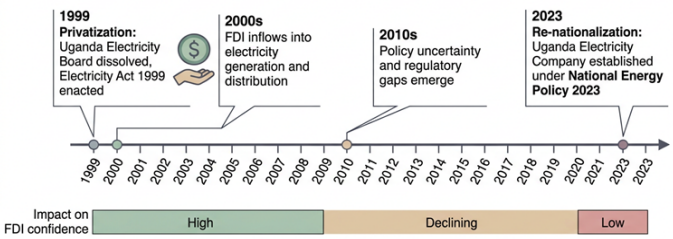
Policy Implications for Uganda and the East African Region

The Uganda case illustrates that energy-sector FDI's growth dividend is contingent on policy stability: the privatization-to-nationalization cycle undermines the investor confidence that the FDI-growth literature identifies as a prerequisite for positive growth effects, and the path forward requires a stable regulatory framework that channels FDI toward the 2% electricity component of Uganda's energy matrix while maintaining biomass-sustainability safeguards for the 89% majority share.

Uganda's electricity sector: privatization, re-nationalization, and FDI uncertainty

Policy reversals in Uganda's electricity sector have created a regulatory-uncertainty discount that deters the long-horizon FDI needed for energy-infrastructure investment, consistent with the broader finding that institutional stability is a threshold condition for FDI-driven growth. Figure 3 traces the key milestones in this policy oscillation. The 1999 privatization of the Uganda Electricity Board (UEB) was enacted through the Electricity Act of 1999, which unbundled the vertically integrated state monopoly into separate generation, transmission, and distribution entities and opened the sector to private investment, particularly FDI. The policy was motivated by the expectation that private capital would finance the expansion of electricity generation capacity, which stood at less than 200 MW at the time, and that competition would improve efficiency. The results were mixed: FDI did flow into the sector, most notably into the Bujagali hydroelectric dam (250 MW), but the expected transformation of Uganda's electricity matrix did not materialize (Mutumba et al., 2024b).

Figure 3:Timeline of Uganda's electricity sector policy evolution (1999–2023)



The 2023 re-nationalization, which consolidated the unbundled entities back into the Uganda Electricity Company (UEC), reversed the 1999 policy and signaled a fundamental shift in the government's approach to energy-sector governance. The national energy policy for Uganda (2023) frames this reversal as a corrective to the failures of privatization, but the empirical evidence on the FDI-growth nexus suggests that the policy oscillation itself — regardless of whether privatization or nationalization is the better model — creates a regulatory-uncertainty discount. Long-horizon investors in energy infrastructure, whose projects have payback periods of 15–30 years, require policy stability to commit capital. A country that oscillates between privatization and nationalization on a 24-year cycle (1999–2023) signals that the regulatory framework is contingent on political cycles rather than on a stable economic logic (Mutumba et al., 2025).

The Uganda case also illustrates the tension between biomass dependence and modern energy investment. With 89% of Uganda's energy matrix consisting of biomass, the electricity sector, which attracts the bulk of energy-sector FDI, accounts for only 2% of total energy consumption. This means that even successful FDI in electricity generation has a limited impact on aggregate energy consumption and, by extension, on the aggregate energy-growth relationship. The policy implication is that FDI policy must be coordinated with biomass-sustainability policy: if FDI in electricity generation displaces biomass consumption, the growth effect may be larger than what the electricity share alone would suggest, because the productivity gains from switching from biomass to electricity are substantial (Wesseh & Lin, 2017).

Regional energy cooperation and clean-energy investment pathways

Regional energy-market integration offers a scale-based solution to the FDI-attraction problem: a regional market with harmonized regulation can attract larger, cleaner-energy FDI flows than any single East African country can independently. The East African Community (EAC), comprising Uganda, Kenya, Tanzania, Rwanda, Burundi, South Sudan, and the Democratic Republic of Congo, has made regional energy-market integration a priority, with the Eastern Africa Power Pool (EAPP) serving as the institutional mechanism for cross-border electricity trade. The economic logic is straightforward: a regional market of over 300 million people with harmonized energy regulation can attract larger-scale FDI than any single member state, and the diversification of energy sources across countries reduces the supply risk that deters investment in individual countries (Adom & Amuakwa-Mensah, 2016).

The empirical evidence on regional energy cooperation in East Africa is limited but suggestive. Wesseh & Lin (2017) examined whether renewable energy can power Eastern African countries' transition to industrialization and urbanization, finding that the potential is substantial but that it requires regional coordination to overcome the scale and intermittency challenges of renewable energy. The EAPP's

strategy of connecting national grids and developing shared generation capacity particularly hydroelectric power from Ethiopia and geothermal power from Kenya is consistent with the FDI-attraction logic: a regional grid reduces the investment risk associated with any single country's regulatory environment and increases the market size that justifies large-scale generation investments.

The clean-energy investment pathway for Uganda is shaped by the country's energy matrix. With 89% biomass, the most immediate growth gains from energy-sector FDI are likely to come from investments that enable the transition from biomass to modern energy, rather than from investments that expand electricity generation for its own sake. This suggests that FDI policy should prioritize off-grid and mini-grid renewable energy solutions that can reach the rural population currently dependent on biomass, rather than large-scale grid-connected generation that primarily serves the urban and industrial electricity demand (Mugume & Bulime, 2024). The institutional preconditions for this strategy — regulatory quality, human capital, and financial development — are the same ones that the absorptive-capacity literature identifies as threshold conditions for FDI-driven growth, reinforcing the centrality of institutional reform to Uganda's energy-growth strategy.

Research Gaps and Evidence-Strength Assessment

The most critical evidence gap is the absence of Uganda-specific multivariate studies that jointly estimate the energy-growth and FDI-growth relationships within a single VECM framework a gap that, once filled, would resolve the current ambiguity about whether energy-sector FDI's growth contribution in Uganda operates through the energy channel, the capital-formation channel, or both.

The Biomass blind spot: why Uganda's dominant energy source is under-studied

The exclusion of biomass from energy-growth models for biomass-dependent economies creates a systematic measurement error: the reported energy-growth relationships for Uganda may reflect only the 11% modern-energy component, leaving the growth contribution of the 89% biomass share unmeasured. This biomass blind spot is not unique to Uganda it affects most Sub-Saharan African countries where biomass dominates the energy matrix but it is particularly acute for Uganda because of the extreme skew toward biomass. The empirical literature on energy-growth causality in developing countries almost exclusively uses commercial energy consumption data from the International Energy Agency (IEA) or the World Bank, which measure electricity, petroleum products, and coal but exclude traditional biomass (Mutumba et al., 2024b). For a country like Uganda, where 89% of energy consumption is biomass, this means that the variable labeled "energy consumption" in empirical studies captures only 11% of actual energy use.

The consequences for inference are substantial. If biomass consumption is positively correlated with economic growth — for example, because biomass is the primary cooking fuel and cooking is a necessary condition for labor supply — then excluding biomass from the model produces an omitted-variable bias whose direction depends on the correlation between biomass and commercial energy. If biomass and commercial energy are substitutes (as electrification policy assumes), the bias is negative: the growth effect of commercial energy is underestimated because the model does not account for the growth effect of the biomass that commercial energy displaces. If biomass and commercial energy are complements (as is the case when biomass is used for cooking and electricity for lighting in the same household), the bias is positive: the growth effect of commercial energy is overestimated because it partly reflects the growth effect of the correlated biomass consumption.

Filling this gap requires data that currently does not exist: time-series estimates of biomass consumption at the national level that are consistent with the commercial energy data used in econometric models. Until such data become available, the evidence on Uganda's energy-growth relationship must be interpreted with the caveat that it reflects only the modern-energy component, and that the growth contribution of the dominant energy source remains unknown.

Evidence-strength comparison across regions and methods

The evidence base for the energy-growth-FDI nexus in Sub-Saharan Africa remains dominated by single-country studies with limited external validity, creating a methodological asymmetry that panel studies with Africa-specific subsamples could address. Comparing the evidence base across regions reveals a stark asymmetry.

Developed-country studies benefit from long time series (50–60 years of annual data), high data quality, and multiple independent replications. The evidence from the United States, Western Europe, and Japan is sufficiently robust to support meta-analyses that identify the moderators of the energy-growth relationship with reasonable precision (Emirmahmutoglu et al., 2021). The evidence from Sub-Saharan Africa, by contrast, is dominated by single-country studies with 30–40 annual observations, limited data quality, and few independent replications. The Uganda-specific evidence, for example, consists of two VECM-based studies by the same research group (Mutumba et al., 2024; Mutumba et al., 2025), which provide internally consistent findings.

The methodological asymmetry extends to the range of methods employed. Developed-country studies have applied time-varying causality, nonlinear ARDL, Markov-switching models, and structural VAR with long-run restrictions, while African studies have largely relied on the standard VECM-Granger framework. This is partly a data constraint — time-varying methods require longer time series than are typically available for African countries — but it is also a capacity constraint: the application of advanced methods to African data requires researchers with both the econometric skills and the country-specific knowledge to interpret the results.

The pollution haven hypothesis has been extensively tested in the context of FDI flows from developed to developing countries, but the evidence for East Africa is thin. Singhania and Saini (Singhania & Saini, 2021) provide a global assessment, but their sample includes few East African countries, and the studies that do include East African countries typically pool them with other regions, obscuring region-specific patterns.

The FDI-energy-growth nexus has been studied for Sub-Saharan Africa as a whole (Olanrele & Awode, 2022), but the regional aggregation may mask important heterogeneity between East Africa, West Africa, and Southern Africa that reflects differences in energy endowments, regulatory environments, and FDI composition.

Conclusions and Recommendations

Conclusion

This paper has conducted a narrative survey of energy use FDI and economic growth within a developing country context; with a case of Uganda a small land locked economy. The three-dimensional policy-investment-evidence framework reveals that the energy-growth-FDI nexus in developing economies is not a single causal mechanism but a configuration of three interacting conditions regulatory-stringency level, renewable-versus-non-renewable FDI composition, and econometric-identification strength and the Uganda case demonstrates that all three must be aligned for energy-sector FDI to translate into sustainable economic growth.

Four empirical patterns emerge from this survey. First, the growth hypothesis dominates for non-renewable energy consumption in

low-income, energy-importing countries, while the conservation and neutrality hypotheses are more prevalent for renewable energy and in middle-income economies. This asymmetry implies that the energy transition in developing countries must be managed carefully: policies that restrict fossil fuel consumption without providing adequate renewable alternatives may carry short-run growth costs.

Second, FDI's growth effect is conditional on absorptive capacity: institutional quality, human capital, and financial development are threshold conditions. Countries below these thresholds experience a trade-off of short-run growth gains against long-run environmental costs, while countries above the thresholds benefit from a positive feedback loop between FDI, clean energy, and growth.

Third, the pollution haven hypothesis is sector-specific rather than universal: it is strongest in low-regulation, resource-extraction sectors and weakest in renewable-energy FDI, where technology transfer dominates the emissions effect.

Fourth, Uganda's policy oscillations in the electricity sector have created a regulatory-uncertainty discount that deters the long-horizon FDI needed for energy-infrastructure investment.

Recommendations

The key recommendation to developing countries in Uganda is to strengthen regulation against FDI that is marked by heavily polluting firms that will damage the environment. The growth ensuing from their investments do not promote sustainable growth in the long run(Khalid et al (2025).

Areas for further research

Three research gaps are particularly urgent. The absence of Uganda-specific multivariate studies that jointly estimate the energy-growth and FDI-growth relationships within a single VECM framework is the most critical gap.

The biomass blind spot the exclusion of the 89% biomass share from energy-growth models creates a systematic measurement error that affects all energy-growth studies for biomass-dependent economies. The limited application of nonlinear and time-varying methods to African data constrains the ability to detect policy-regime shifts and asymmetric effects. Filling these gaps requires not only new data particularly time-series estimates of biomass consumption but also the application of advanced econometric methods to existing African data, and the development of panel datasets with Africa-specific subsamples that can support cross-validation of single-country findings.

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