GLOBAL ENERGY ACCESS NETWORK

Case Study Volume IV

Energy Resilience, Transition and Equity

Edited by Ananya Aggarwal, Josh Salzberg, Ran Lan

Published by the Global Energy Access Network (GLEAN)

https://sites.duke.edu/glean/

Cover image courtesy Asian Development Bank

Published April 2026

Table of Contents

Foreword 4

Ananya Aggarwal, Josh Salzberg, Ran Lan

Beyond Generation: Addressing the Structural Challenges of Ethiopia's Energy Transition 6

Judy Hua Zhu, Lauren Shohan, Manjiri Deshmukh

Fiscal Sacrifice for Economic Survival: Analyzing the Trade-off between EV Tax Exemptions and Fuel Import Savings in Ethiopia 19

Yeeun Kim

Nigeria's Energy Transition Plan: Feasible or Fiction? 33

Ozioma Ozigbo

Powering Peace: Unpacking The Humanitarian Energy Gap In Northeastern Nigeria's Displacement Settings 44

Madeline Sachtler

Switching on Opportunity: Measuring Energy Access in South Asia through the Lens of Education, Gender, and Stratification Economics 53

Asreeta Ushasri, Kanishka Desai

Policy Improvements for Alleviating Elderly Energy Poverty in South Korea 64

Jiyeong Pyo

Struggles Post-Universal Energy Access: Viet Nam's Energy Transition 72

Ananya Aggarwal, Jessalyn Chuang, Malaika Martis

Foreword

Ananya Aggarwal, Josh Salzberg, Ran Lan*
Master of Environmental Management, Nicholas School of Environment, Duke University
*& Master of City & Regional Planning, University of North Carolina Chapel Hill

Sustainable Development Goal 7 aims to ensure access to affordable, reliable, sustainable and modern energy for all (*Goal 7,* n.d.). In an era where global electricity demand is accelerating, the importance of this goal cannot be overstated. According to the International Energy Agency's *Electricity 2026* report, increasing global demand through 2030 is largely to be driven by increased cooling and heating requirements, the expanded role of electricity in building operations, the uptake of electric vehicles, and the rapid global expansion of data centers (IEA, 2026). Growing electricity systems are powering life and livelihoods more than ever before. Yet 730 million remain without electricity access (IEA, 2025), and, as one of our articles discusses, measures of power reliability and quality remain sadly inadequate. While there are no easy answers, we are proud to present a selection of thought-provoking pieces in this collection.

The Global Energy Access Network (GLEAN) is an interdisciplinary network of graduate and undergraduate students at Duke. With support from James E. Roger Energy Access Project, we aim to create a forum for students, staff, faculty and visitors of the Duke University community to explore the many knowns and unknowns about our energy futures. One platform is the Case Studies volumes, of which this edition is the fourth. With this publication we are excited to reinaugurate the annual release of GLEAN Case Studies. As an outlet for research by the Duke community, these volumes give voice to pressing issues in energy access from multidisciplinary vantages, reflecting the three master's programs from which our authors hail. As we re-enter our annual cadence, we look forward to further embedding these multidisciplinary perspectives into all our work. We hope this volume sparks new questions, challenges assumptions, and contributes to a more grounded and constructive dialogue on the future of energy access

Enclosed you will find a wide range of topics covering Nigeria, Ethiopia, South Asia, and South Korea.

- Zhu, Shohan and Deshmukh examine structural challenges that impede Ethiopia's energy transition and argues for the need for coordinated reforms, investment, and institutional change.
- Kim analyzes the tradeoffs of Ethiopia's policy to shore up foreign exchange reserves by banning the import of internal combustion vehicles, thereby reducing dependence on oil imports.
- Ozibgo evaluates the conditional feasibility of Nigeria's ambitious 2060 carbon neutrality plan against the backdrop of the 2016 black soot crisis, arguing that a just transition is already emerging from the bottom up through community-driven innovation
- Sachtler examines why national energy access initiatives systematically exclude Nigeria's most vulnerable communities as northeastern Nigeria's displacement crisis deepens, and makes the case for hybrid solar-diesel infrastructure
- Ushasri and Desai compare national energy access survey methodologies in use in India and Nepal through stratification and feminist economics.
- Pyo reviews South Korean energy welfare policy efficacy in reaching the elderly populations who need it most.
- Aggarwal, Chuang and Martis explore how aligning domestic priorities with international financing can enable a transition toward a more reliable, affordable, and resilient low-carbon energy system, using BESS in Viet Nam as a case.

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Beyond Generation: Addressing the Structural Challenges of Ethiopia's Energy Transition

Judy Hua Zhu, Lauren Shohan, Manjiri Deshmukh

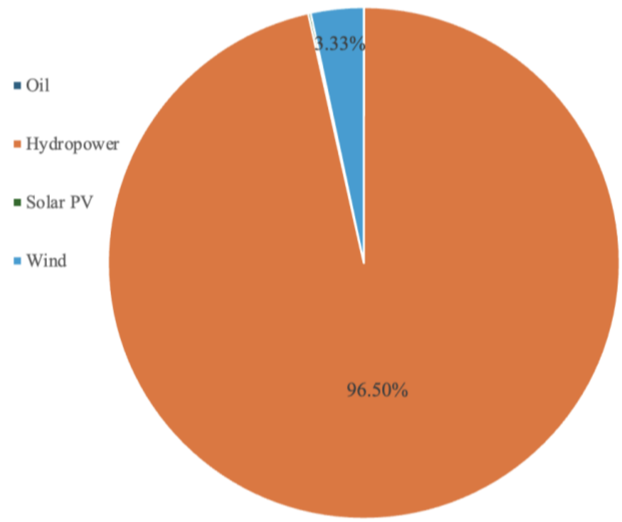
Master of Environmental Management (MEM '26), Nicholas School of Environment, Duke University

EXPLORING ETHIOPIA'S MACROECONOMIC OUTLOOK

The East African country, Ethiopia, is key for understanding the transition of an agrarian economy when faced with the threat of climate change, strong economic pressures, and geopolitical stress. Ethiopia has been the recipient of foreign aid for a long time; however, in the last two decades the country has experienced an accelerated rate of economic growth driven by investments in infrastructure and agriculture (Paul et al., 2012).

Ethiopia's domestic electricity generation is predominantly renewable, with hydropower accounting for almost 97%, followed by wind power (3.33%) and extremely minor contributions from oil and solar PV, as of 2023. It is key to note that until 2015, Ethiopia was heavily reliant on fossil fuels imports (8.3% of energy consumption). Owing to the country's vulnerability to international pricing, Ethiopia has since actively slashed fossil fuel usage, resulting in a negligible fossil fuel consumption in 2023 (World Bank, n.d.).

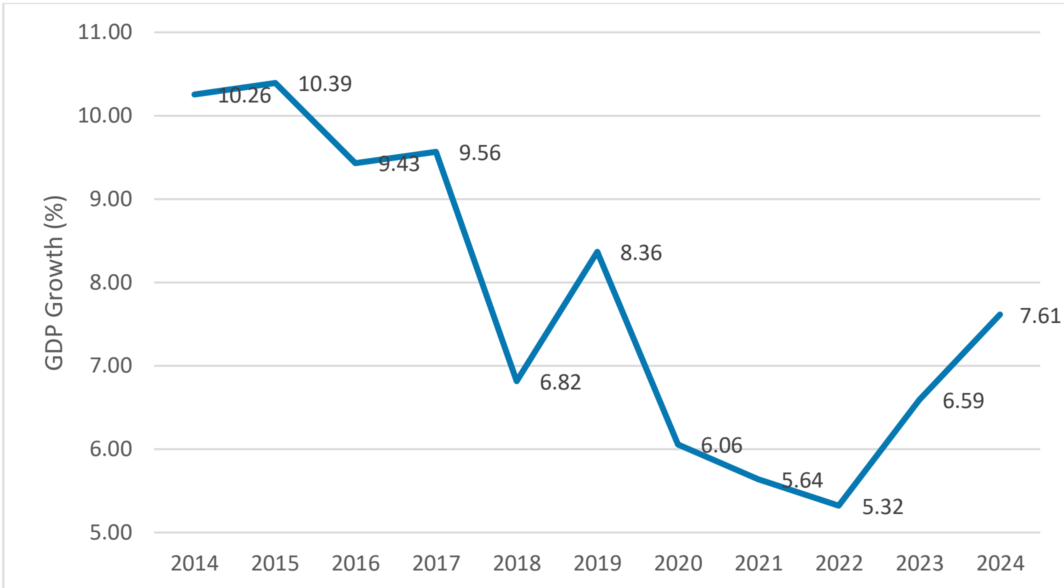
Figure 1. Electricity Generation Sources, Ethiopia, 2023



Source: International Energy Agency, 2023

Despite progress, the energy sector continues to face critical gaps in grid connectivity, reliability and infrastructure, institutional capacity, and regulatory maturity (Ministry of Water and Energy et al., 2025). Ethiopia's core challenges include slow electrification, overreliance on biomass, aging grid infrastructure, and slow regulatory reforms. Yet there are still ample opportunities such as rapid EV adoption, expanded regional power exports, untapped geothermal and solar resources. Beyond energy, Ethiopia is also endowed with abundant mineral resources, including coal, iron ore, tantalum, etc (Eze, 2025). Strategic development of both energy and mineral resources could provide the country with a stronger foundation for economic growth, regional trade, and long-term resilience.

Figure 2. GDP Growth for Ethiopia (2014-2024)



Source: GDP Growth (annual %), Ethiopia, World Bank

Ethiopia has displayed impressive GDP growth over the years, averaging 8% from 2014 to 2024 (Figure 2). However, much of this progress has bypassed the rural poor. Where there is an impressive 94% electrification rate in urban areas, the energy access rate in rural areas remains at 44% (Lee & Liao, 2026). Despite growing solar and hydropower capacity, the vast majority of households continue to rely on biomass for cooking and heating, thus highlighting the rural-urban divide in access to electricity. Ethiopia's experience thus highlights important lessons on the need for equitable development, more balanced dispersion of aid, and inclusive investment strategies in the face of climate change.

INTRODUCING ETHIOPIA'S ENERGY LANDSCAPE

I. Energy Access in Ethiopia

Symbolic of Ethiopia's push for self-sufficiency, the Grand Ethiopian Renaissance Dam (GERD) was officially completed in 2024 and has a maximal capacity of 5,150 MW (Rijntalder, 2025). The dam, one of Africa's most powerful, has enhanced national production capacity and placed Ethiopia's capital city, Addis Ababa, as an African leader in renewable energy. Despite the growth in energy generation, the path to universal electricity access for Africa's second-most populous country remains challenging due to lacking transmission and distribution infrastructure. The current grid consists of 20,390 km of transmission lines and 179,000 km of distribution lines, a level still insufficient to cover the entire territory (Diop, 2025). According to the National Energy Compact published by the World Bank's Mission 300 initiative, as of 2025, only 44% of Ethiopians currently benefit from a baseline electric service, and rural areas, which house roughly 80% of Ethiopians, face limited and unreliable energy access.

II. Reliability Constraints

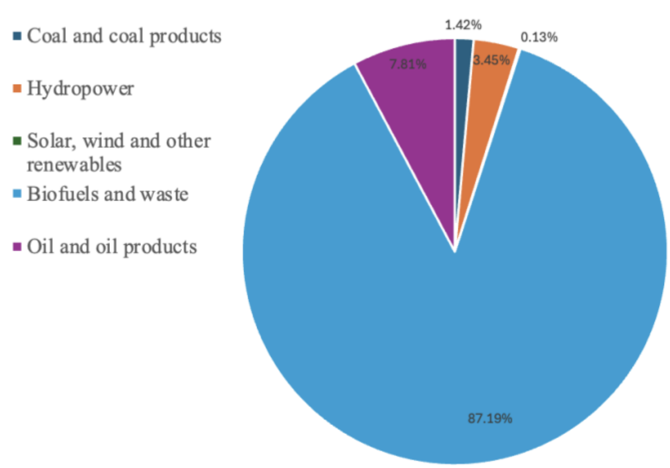
Body System losses further exacerbate service reliability and constrain access rates, with transmission losses at 6%, distribution losses at 22%, and commercial losses at 10% (Diop, 2025). This could be attributed to the outdated and under-maintained grid infrastructure, leading to frequent interruptions, as System Average Interruption Duration Index (SAIDI) stands at an average 21 hours per month (Ayele, 2025).

Thus, it is evident that reliability of electricity supply remains a major issue, particularly in rural areas and secondary towns, where aging infrastructure, weak voltage regulation, and technical losses affect service quality. A potential solution to address the reliability challenge is to enhance investment in grid expansion, however high costs and weak last-mile connections to households pose a hurdle (World Bank, 2025).

III. Lack of a Diversified Energy System

Body According to the IEA, in 2023, Ethiopia's total final energy consumption is dominated by biofuels (87%), followed by oil products (8%), and hydropower (3.5%). Most biofuels are consumed directly (rather than being converted into electricity), which reflects the lack of energy access in rural regions.

Figure 3. Total energy consumption, Ethiopia, 2023



Source: International Energy Agency, 2023

Ethiopia is lacking severely in access to modern energy supplies. The majority of Ethiopia's population lives in rural areas and is heavily reliant on agriculture. Hence, the key source of energy for the rural population is biomass (biomass of wood, solid, and agricultural wastes), reinforcing biomass reliance and deepening energy poverty (Philipp, 2023). Moreover, Ethiopia has enormous biomass energy potential, but it is not being utilized efficiently and effectively. Ethiopia's estimated exploitable biomass potential and currently exploited biomass potential are 141.8 and 70.9 million tons per year, respectively (Benti et al., 2021). Thus, 92% of households continue to depend on traditional biomass for cooking, posing serious risks to health, gender equality, forests and biodiversity, and economic productivity (World Bank, 2025).

Energy poverty, resulting from a lack of access to reliable, affordable and essential energy resources, is a pressing issue especially in rural areas of Ethiopia (Climate Policy Database, 2024). Energy insecurity thus arises from the lack of a diversified energy system with an overreliance in biofuels. Ethiopia's prior dependence on imported petroleum fuels and international price volatilities had led Ethiopia to establish a ban on the import of Internal Combustion Engine (ICE) vehicles in January 2024 (Climate Policy, 2024), becoming the first country to implement such a policy (International Energy Agency, 2019). However, this rollout faces significant challenges, with Ethiopia having only one public EV charging station as of late 2024 (Barham, 2024). The government encourages community-based chargers rather than public infrastructure, with affordability concerns persisting (Ministry of Water and Energy et al., 2025).

At the same time, recurring drought intensifies the energy challenge. Around 90% of electricity generation depends on hydropower, leaving the system highly vulnerable to reduced water availability. During drought periods, dam output falls significantly below installed capacity. When considered holistically, grid instability and unreliability, driven by hydropower variability (from weather and regional hydro-politics), raises further uncertainty for widespread EV adoption.

IV. Addressing Energy Insecurity to Alleviate Women Health and Empowerment

Energy poverty in Ethiopia also continues to undermine public health and living standards. Heavy reliance on wood and charcoal for cooking and heating exposes households to harmful indoor air pollution, leading to widespread respiratory illnesses caused by prolonged inhalation of smoke from inefficient combustion. Limited access to electricity also restricts ventilation options and cleaner cooking technologies, compounding indoor air quality problems in homes dependent on biomass fuels.

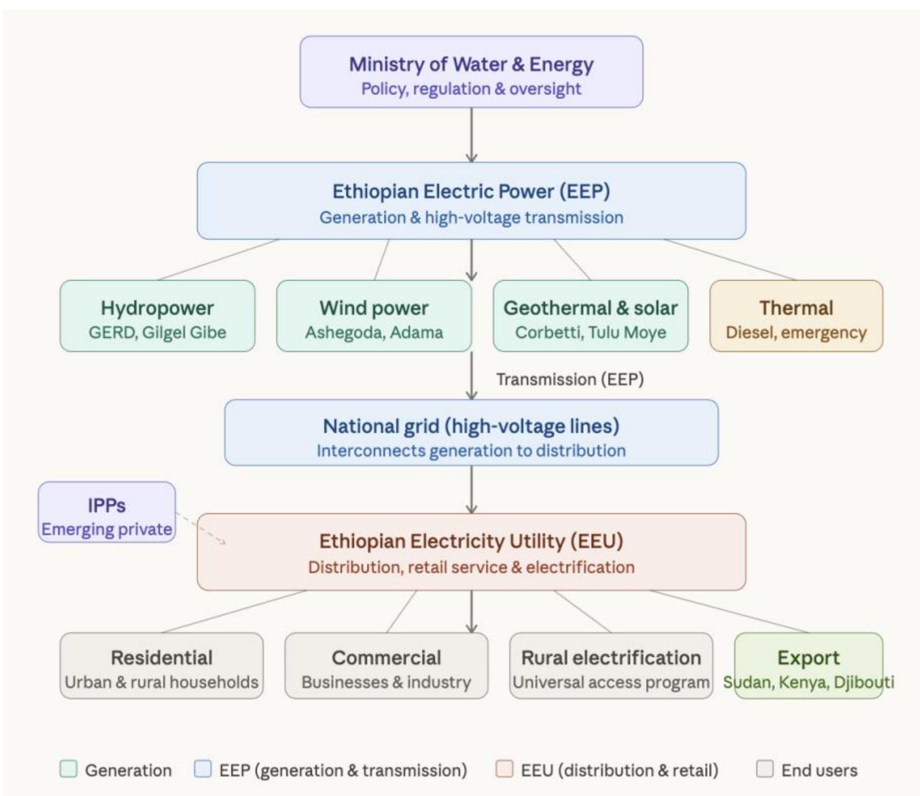
Ethiopia has also begun to confront the gendered dimensions of energy access and employment. Even where transmission lines reach nearby communities, only about one-third of households, one-quarter of primary schools, and one-third of health clinics have grid electricity access, illustrating persistent infrastructure and equity gaps that disproportionately affect women and girls. Women are particularly disadvantaged not just because they constitute the majority of households managing energy needs, but also because they are under-represented in the institutions that shape the energy sector itself. In the workforce of the national utility, women account for only 20 percent of employees and even fewer hold technical positions, reflecting structural barriers to participation and leadership (World Bank, 2019).

Efforts to expand access and equity have included targeted policy reforms, training programs, and institutional shifts to elevate women's roles in planning and delivery. These gender-focused initiatives form an important complement to infrastructure expansion, underlining that technical solutions alone cannot resolve the entrenched inequities that shape energy poverty in Ethiopia.

V. Ethiopia's Energy Regulatory Structure

Ethiopia's energy sector is highly centralized and vertically integrated, with the Ethiopian Electric Power (EEP) overseeing almost all generation and transmission, and Ethiopian Electricity Utility (EEU) managing distribution, retail service, and electrification program.

Figure 4. Regulatory Structure of Energy, Ethiopia



Source: UNECA & RES4Africa Foundation, 2021

The utility has demonstrated a robust increase in revenue, recording a 35% increase in their Earnings Before Interests, Taxes, Depreciation and Amortization (EBITDA), indicating that the core business of generating and selling power is sound and profitable. However, these gains are offset by extremely high financing costs and depreciation from past capital investments, resulting in significant net losses over time.

The country is in the process of establishing a new framework liberalizing power generation and enhancing competition through Independent Power Producers (IPPs). Two solar photovoltaic projects namely Gad and Weransso are already in development (Capital Ethiopia, 2025). However, key barriers to deregulating the regulatory structure include the absence of a fully independent regulator, and financially constrained state utilities that struggle with cost recovery and reliance on subsidized tariffs (World Bank Group, 2024; Addis Insight, 2025). Currently, EEP serves both as a producer and system operator, a structure potentially leading to conflicts of interest as private generation is on the rise (World Bank, 2024). In addition, political and economic priorities, particularly maintaining affordability, expanding access, and retaining state control over a strategic sector, have led to a cautious, incremental approach to reform. Therefore, until regulatory reforms deepen, private sector participation and market competition will remain constrained.

POLICY RECOMMENDATIONS TOWARDS A RENEWABLE AND RELIABLE FUTURE

Ethiopia possesses abundant renewables, strategic geography, and growing regional energy demand, yet structural and institutional barriers continue to prevent these advantages from being fully realized. Progress depends not on any single intervention, but on advancing a coordinated set of reforms across four interconnected areas: deregulating the market, restoring stability in conflict-affected regions, modernizing grid infrastructure, and strategically developing the country's critical mineral resources. Together, these recommendations offer a pathway to an energy system that is not only renewable, but resilient, competitive, and capable of driving long-term economic growth.

I. Progress towards Regulatory Reform and Openness of Competition

Regulatory integrity and clarity of responsibilities in the current operation system remains limited. Both EEP and EEU operating as state-owned monopolies restricts competition and the entry of Independent Power Producers (IPP) has been slow. EEP currently acts as the single buyer of electricity from IPPs under long-term power purchase agreements, a model that ensures revenue certainty but concentrates market power in one entity. As the Eastern Africa Power Pool (EAPP) advances toward launching regional power trade, with market and centralized trading systems targeted for 2025-2026 (African Energy Chamber, 2026), competition may gradually be introduced into the Ethiopian electricity system, particularly if an independent transmission system operator (TSO) is enacted.

To strengthen Ethiopia's energy system and accelerate its transition toward sustainable and reliable electricity access, the government should adopt a policy framework that actively incentivizes private and commercial investment, both domestically and internationally. At present, all generation assets are state-owned, limiting capital inflow and innovation. Promoting IPPs and private developers to participate in both generation and system expansion would diversify financing sources, enhance project efficiency, and accelerate the deployment of renewable technologies such as wind, solar and battery. Transparent regulatory mechanisms, fair power purchase agreements, and streamlined licensing processes are critical to reducing investor risk and building market confidence. These reforms would not only improve supply reliability but also encourage competitive pricing and technology transfer, essential for Ethiopia's long-term energy security.

A top priority should be implementing the proposed independent TSO which will be separate from EEP and be used to manage system operations, dispatch, and transmission planning. This separation would increase transparency in grid decisions, reduce conflicts of interest, and build investor confidence by having a separate entity responsible for dispatch (Capital Ethiopia, 2025).

II. Addressing the Domestic Security Challenges in the Country

Spanning decades, tensions between the Ethiopian government and the Tigray People's Liberation Front (TPLF) boiled over into a war in 2020, which involved regional militias and federal forces. The fighting has caused massive human suffering, displacement and severe security threats (House of Lords Library, 2022). These security challenges caused by the conflict in the regions of Amhara, Tigray, and Oromia pose substantial risks which are affecting investor trust and the movement of goods safely.

Hence, addressing these internal issues would serve as the foundation to building safe, secure and stable progress in the sector. Ethiopia's success in attracting and retaining major solar investments will depend on stability and predictability is intrinsically linked to the presence of a stable and predictable operating environment. The scale and intensity of the domestic crisis in the country requires international cooperation, as the political and financial burden of delivering a robust solution cannot be borne by one country alone (Sany & Sheehy, 2022). Between 2020 and 2022, the conflict devastated infrastructure and displaced 800,000 people in the Tigray region (ESNFI Cluster, 2025). The war also damaged or vandalized 514 health posts and 153 health centers, and the share of health posts with electricity, many powered by solar systems, fell from about 60.9% before the conflict to just 11% afterward, highlighting the scale of infrastructure losses and the need for external support to restore essential energy services (CESET Project, 2024).

The core challenges spanning dispersed rural populations, limited fiscal capacity, and infrastructure damaged or delayed during periods of instability such as the Tigray War, have prompted collaboration with international development partners. One such example is the Access to Distributed Electricity and Lighting in Ethiopia (ADELE) project, financed through concessional loans from the International Development Association of the World Bank, which aims to expand electricity access while promoting gender inclusion and institutional capacity within Ethiopia's energy sector (World Bank, 2021). These partnerships are implemented in coordination with Ethiopian ministries and utilities, allowing international organizations to provide financial and technical resources while respecting national ownership of energy policy and development priorities. Scaling up international partnerships modelled on ADELE, paired with dedicated funding streams for conflict-damaged energy infrastructure, will be essential to restoring the foundation on which Ethiopia's energy transition depends.

III. Strengthening Grid Stability and Reliability

A critical area of focus should be maintaining a consistent and reliable supply of competitively priced electricity from GERD for large-scale, energy-intensive manufacturing. As reported by EEU's CEO in 2025, end-user electricity tariffs have been established at $0.005/kWh for residential use and $0.012/kWh for commercial use, which are amongst the lowest in Africa (The Reporter Ethiopia, 2026). However, the reliability of the grid has remained a pertinent challenge - investments in improving reliability would be crucial.

Ethiopia should capitalize on its exceptionally low-cost renewable generation potential by strengthening grid stability and increasing firm power capacity through private investments in grid modernization, energy storage, and flexible generation technologies. Enhanced interconnections and transmissions with neighboring countries would allow Ethiopia to export its surplus electricity, fostering regional energy integration and generating foreign currency revenue. Upgrading transmission infrastructure and operational efficiency would also mitigate its reliability issues, ensuring the power meets domestic and exported demand reliably. This sheds light on the fact that focus must be laid on modernizing the electrical system, as transmission and distribution networks are also projected to expand significantly by 2030 (Diop, 2025).

IV. Enhancing investment in energy diversification and building mineral resources in Ethiopia

Ethiopia's energy transition and mineral sector development are mutually reinforcing opportunities that, taken together, can strengthen the country's long-term economic resilience. As highlighted by the World Bank, the country possesses significant geological potential across a range of minerals, though the sector remains constrained by gaps in governance, data, and institutional capacity (World Bank, 2015). Ethiopia holds a rich repository of emerging critical minerals such as lithium and tantalum, which would serve crucial to fuel its role in the global energy transition movement (SFA (Oxford), n.d.).

The sector already contributes to foreign exchange earnings and livelihoods, particularly through artisanal and small-scale mining, but its broader economic impact is limited by informality, low value addition, and regulatory challenges (AFSIC, 2024). Strategic reforms such as strengthening governance frameworks, improving geological data systems, formalizing mining activities, and promoting downstream processing will be essential to fully leverage mineral resources. Pursued in parallel with energy diversification, these reforms offer Ethiopia a compounding opportunity: infrastructure development, expanded regional trade, and a stronger foundation for sustainable, long-term growth.

CONCLUSION—LAYING THE TRAJECTORY FOR ETHIOPIA'S PATH FORWARD

Ethiopia has made meaningful strides in confronting energy poverty. The completion of the Grand Ethiopian Renaissance Dam, ambitious targets to triple installed capacity to 17,000 MW by 2035 from its existing 5,250 MW (International Trade Administration, 2024) and growing international partnerships through initiatives like Power Africa and the ADELE project all reflect a government increasingly committed to energy transformation. Yet generation capacity alone has not translated into reliable, inclusive access. Ethiopia's energy potential is exceptional, however the gap between that potential and the lived experience of most Ethiopians remains substantial.

While structural constraints persist, Ethiopia must pursue a multi-pronged strategy to open the market to private power producers through regulatory reform; address domestic insecurity in conflict-affected regions, supported by international partnerships and targeted infrastructure restoration; modernize the grid to convert Ethiopia's low-cost generation advantage into reliable supply; and strategically develop critical mineral resources. These initiatives have the potential to reduce poverty, improve health outcomes, and narrow educational disparities. Although significant work remains, sustained investment and institutional commitment are central to advancing Ethiopia's long-term energy security and inclusive development objectives.

This paper has focused primarily on the supply-side and institutional dimensions of Ethiopia's energy challenge. Future research could potentially examine the distributional effects of tariff reform, particularly how pricing adjustments affect low-income rural households, as well as the gender dimensions of energy access. The evolving role of the Eastern Africa Power Pool as a vehicle for regional energy integration, and Ethiopia's potential positioning within emerging global critical mineral supply chains, also merit dedicated analysis as both are likely to shape the country's energy and economic trajectory in the decade ahead.

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Fiscal Sacrifice for Economic Survival: Analyzing the Trade-off between EV Tax Exemptions and Fuel Import Savings in Ethiopia

Yeeun Kim

Master of Environmental Management (MEM '26), Nicholas School of Environment, Duke University

INTRODUCTION

In January 2024, Ethiopia became the first country in the world to ban the import of internal combustion engine (ICE) vehicles. This policy decision was mainly driven by a chronic economic crisis: exchange shortages caused by massive fossil fuel imports. Ethiopia spends roughly $4.5 billion to $7.6 billion annually importing fuel (Harter, 2025), representing about 15% of the country's total merchandise imports (World Bank, n.d.). As Transport Minister Bareo said, fuel imports constitute "one of our main expenditures," consuming enormous proportions of the country's foreign currency reserves (Harter, 2025).

The transportation sector is the main consumer of imported fossil fuels. In 2018, transportation accounted for 54% of Ethiopia's final fossil fuel consumption (Yalew, 2022). This huge take-up is driven by the country's vehicle fleet situation. The country's automotive market is dominated by second-hand imported vehicles, which comprise around 85% of all vehicles on Ethiopian roads (UNCTAD, 2024). The majority of these vehicles are older than 15 years and beyond their useful service life, resulting in high fossil fuel consumption rates (ibid.). Had Ethiopia continued importing ICE vehicles and fossil fuels, its foreign exchange reserves would have continued to dwindle.

Thus, the Ethiopian government launched a groundbreaking policy: banning ICE vehicle imports while encouraging electric vehicles (EVs) imports with substantial tax incentives. The original policy covered only fully assembled ICE units, allowing semi-knocked-down (SKD) and completely knocked-down (CKD) ICE vehicle kits to be imported and assembled domestically (Joseph, 2025). However, in May 2025, the Ministry of Industry extended the ban to all SKD and CKD kits for automobiles, three-wheeled vehicles, and motorcycles (ibid.), which may boost EV adoption and exchange savings.

However, this policy creates an economic trade-off. While each EV eliminates fuel import expenditures that drain scarce foreign exchange reserves, the government sacrifices substantial tax revenues by exempting EVs from most import duties and consumption taxes that would otherwise be collected on ICE vehicles and fossil fuel imports. Therefore, the question becomes: does the long-term reduction in fuel import costs outweigh the immediate fiscal sacrifice of foregone tax revenues?

This case study presents a quantitative analysis of this trade-off. I examine whether the foreign exchange savings generated by reducing fossil fuel imports through EV adoption exceed the tax revenues the government sacrifices by providing EV incentives. By determining the break-even point at which this policy becomes economically viable for Ethiopia, I assess whether Ethiopia's incentives on electric mobility could be an economic defense mechanism to recover foreign exchange shortages.

ETHIOPIA'S VEHICLE TAXATION LANDSCAPE

The following taxes are levied on vehicles imported to Ethiopia: customs duty, excise tax, VAT, surtax, and withholding tax. Among these, excise tax varies depending on the cylinder capacity of the spark-ignition engine and the lifetime of the used cars, which ranges to 10% to 500%. For example, according to Excise Tax (Amendment) Proclamation No. 1229/2020, announced in 2020, a 5% excise tax is imposed on new CKD three-wheeler motor vehicles, while a 500% excise tax is imposed, for example, on a seven-year-old CKD three-wheeler with a cylinder capacity exceeding 1800cc. Thus, the total taxes levied on ICE vehicle imports range between a minimum of approximately 79% to a maximum over 500%.

However, when importing EVs, only customs duty and withholding tax are applied, and other taxes are exempted. The customs duty ranges 0% to 15%: 0% to CKD, 5% to SKD, and 15% to fully assembled EVs. Thus, the total taxes levied on EV imports range from 3% to 18%. Table A illustrates this substantial tax differential, showing that while ICE vehicles face cumulative taxes of 73-563%, EVs incur 3-18%, which creates a gap that forms the basis of the government's fiscal sacrifice.

Table A. Tax Comparison of ICE Vehicle VS. EV

	ICE vehicle	EV
Customs Duty	35%	0-15%
Excise Tax	10%- 500%	0%
VAT	15%	0%
Surtax	10%	0%
Withholding tax	3%	3%
Total	73% - 563%	3-18%

Source: Excise Tax (Amendment) Proclamation No. 1229/2020.

Note. Tax rates represent statutory rates applied to the Cost, Insurance, and Freight (CIF) import value. Customs duty for EVs varies by assembly level (0% CKD, 5% SKD, 15% fully assembled). Excise tax for ICE vehicles varies by engine displacement and vehicle age.

ECONOMIC MODELING OF FOREX SAVINGS ANALYSIS

I. Methodology

This study uses a cost-benefit analysis framework to evaluate Ethiopia's EV incentive policy over a ten-year period (2024-2033) from when it started. The analysis quantifies two economic flows:

1. Fiscal Impacts: How much tax revenue the government will sacrifice through EV import duty exemptions
2. Forex Impacts: How much forex expenditure will be saved by reducing fossil fuel imports

For calculations, the analysis uses a fleet-based vintage model that tracks cumulative EV adoption year by year. The major calculations are as follows:

<u>Annual Fiscal Sacrifice</u> = (Tax Loss per New EV × New EVs Added)
+ (Foregone Fuel Tax × Total EV Fleet)
- (Electricity Revenue × Total EV Fleet)

<u>Annual Forex Gain</u> = (Fuel Import Savings × Total EV Fleet)
- (EV Import Premium × New EVs Added)

The details of each element calculation are as follows:

- Tax Loss per EV = (ICE tax rate × ICE price) - (EV tax rate × EV price)
- Foregone Fuel Tax = Annual fuel consumption per vehicle × Fuel price × 30% tax rate (Tax rate of 30% applies from 2026 according to the policy)
- Fuel Import Savings = Annual fuel consumption per vehicle × Fuel price
- EV Import Premium = EV CIF price - ICE CIF price

- NPV = Σ (Cash Flow_t) / (1 + 0.10)^t (All future cash flows are discounted to present value using a 10% discount rate)

The research question is: At what point, if any, do cumulative forex savings exceed cumulative fiscal sacrifices, making the policy economically viable?

II. Key Variables and Assumptions

Ethiopia has set a goal of reaching 500,000 cumulative EVs by 2030 (Harter, 2025). To model this goal, the analysis assumes a uniform annual adoption rate of 77,000 EVs over the 2026-2033 period, resulting in a total fleet of 770,000 EVs by 2030. In addition, all vehicles are assumed to have the same operational characteristics, including the annual mileage (28,800 km), energy efficiency (12 km/L for ICE, 8 km/kWh for EVs), and vehicle lifetime (10 years). The analysis also assumes perfect substitution, where each EV imported replaces one ICE vehicle. While these assumptions do not fully explain Ethiopia's vehicle market, they provide a baseline for comparing the fiscal and foreign-exchange implications caused by the EV incentive policy.

Table B. Vehicle Specs Assumption

	ICE vehicle	**EV**
CIF Price ($)	8,000	15,000
Annual Mileage (km)	28,800	28,800
Fuel Economy (km/l)	12	-
Energy Efficiency (km/kWh)	-	8
Lifetime (year)	10	10

Source: hamrawiadvisory.com (2023), Amanuel et al. (2025), Gebisa et al. (2022)

Regarding the fleet tax, excise taxes on ICE vehicles, which range from 10% to 500%, create too many variations. Considering the costs of used cars Ethiopian might be willing to buy, the analysis assumes a 250% excise tax. The customs duty on EVs ranges from 0% to 15% based on the degree to which the vehicles are assembled. While Ethiopia is trying to develop domestic EV assembly capabilities, the current shortage of skilled technicians and the lack of training infrastructure are challenges to achieving full local assembly. Given these constraints, the analysis assumes that electric vehicles are imported in Semi-Knocked Down (SKD) form, which requires partial domestic assembly, feasible within Ethiopia's current technical capacity. Thus, a customs duty rate of 5% is applied to EVs' custom duty.

Table C. Fleet Tax Assumption

	ICE vehicle	EV
Customs Duty	35%	5%
Excise Tax	250%	0%
VAT	15%	0%
Surtax	10%	0%
Withholding tax	3%	3%
Total	313%	8%

Based on the National Bank of Ethiopia (NBE), the exchange rate as of March 2026 is 156 ETB/USD. This rate is held constant throughout the analysis period. A 10% discount rate is applied to calculate net present values. Regional practice for East African infrastructure projects commonly employs 8-12% discount rates (World Bank, 2016). The 10% rate thus represents a midpoint appropriate for long-term policy evaluation in Ethiopia's context.

Table D. Economic Indicators (Fixed Parameters)

	Value
Exchange Rate (ETB/USD)	156
Discount Rate (%)	10
Period (years)	10

Source: NBE, March 2025

The analysis employs time-varying fuel prices, reflecting Ethiopia's fossil fuel subsidy elimination. Actual retail gasoline prices are used for 2024-2026 ($0.58 to $0.79 per liter), sourced from GlobalPetrolPrices.com. These prices show an annual growth pattern averaging 16.8%. Prices for 2027- 2029 are projected using this 16.8% growth rate as complete subsidy removal happened in May-June 2025 (IMF, 2024; Ministry of Trade, 2025). The fuel prices reach the global average of $1.26 per liter (GlobalPetrolPrices.com, 2026) by 2029, and it is assumed to stabilize at this level from 2029 onward. The introduction of fuel excise taxes, beginning at 0% in 2024, rising to 10% in 2025, and reaching 30% from 2026 onward. This reflects Ethiopia's recent policy announcement.

Table E. Economic Indicators Assumption (Time-Varying Parameters)

Year	2024	2025	2026	2027	2028	2029	2030	2031	2032	2033
Fuel Imports Price ($/L)	0.58	0.65	0.79	0.79	0.79	0.79	1.26	1.26	1.26	1.26
Fuel Tax Rate (%)	0	10%	30%	30%	30%	30%	30%	30%	30%	30%
Electricity Tariff (ETB/kWh)	2.2	4.03	5.86	7.7	9.53	11	12	13	14	15

The Ethiopian Electric Utility (EEU) announced the rolling increase in electricity tariffs starting from 2024 to 2028. The customers will experience a huge cost escalation, averaging 400% by 2028 (Hailu, 2024). To determine the electricity tariff tier for EV charging, I calculated household-level electricity consumption. According to Our World in Data, Ethiopia's per capita electricity demand was 128 kWh in 2023. Assuming an average household size of four persons, baseline household consumption is calculated as follows:

128 kWh/person/year ÷ 12 months ≈ 10.7 kWh/person/month

10.7 kWh/person/month × 4 persons/household ≈ 43 kWh/household/month

Adding EV charging demand to this baseline:

Annual EV electricity: 28,800 km/year ÷ 8 km/kWh = 3,600 kWh/year

Monthly EV electricity: 3,600 kWh/year ÷ 12 months = 300 kWh/month

Total household consumption: 43 kWh/month + 300 kWh/month = 343 kWh/month

This total consumption of 343 kWh/month places EV-owning households in the 301-400 tier of Ethiopia's electricity tariff structure, which increases from 2.2 ETB/kWh in 2024 to 9.53 ETB/kWh by 2028 (Table F).

Table F. A Four-Year Electricity Tariff Adjustment Plan

Power Usage (kWh)	Year-End Tariff (ETB/kWh)				
	2024	2025	2026	2027	2028
51-100	0.77	1.49	2.21	2.94	3.66
101-200	1.63	2.67	3.72	4.76	5.81
201-300	2	3.84	5.68	7.52	9.35
301-400	2.2	4.03	5.86	7.7	9.53
401-500	2.41	4.17	5.94	7.71	9.48
500-above	2.48	4.23	5.97	7.72	9.46
Commercial	2.12	4.05	5.98	7.9	9.83

Note. Table summarizes the progressive electricity tariff schedule under Ethiopian Electric Utility's four-year adjustment plan (2024-2028). Rates are in Ethiopian Birr per kilowatt-hour. Source: Shega (2024).

III. Results

The economic analysis (2024-2033) shows that the Ethiopia government should sacrifice more than what it gains from the foreign exchange savings. The fiscal sacrifice of foregone tax revenues outweighs the reduction in fuel import costs. Specifically, Ethiopia's electric vehicle incentive policy generates a loss in net benefit of $10,050 million (NPV), with fiscal sacrifices of $12,656 million, offset by foreign exchange gains of $2,606 million.

Table G. Economic Analysis of Electric Vehicle Policy Results

	1	2	3	4	5	6	7	8	9	10
Fleet	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**	**2032**	**2033**
EV new (vehicles)	35,000	80,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000	77,000
EV stock (vehicles)	35,000	115,000	192,000	269,000	346,000	423,000	500,000	577,000	654,000	731,000
Fiscal Impact ($ Million)										
Tax loss per new EV	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238	0.0238
Total tax loss (new EVs from 2024)	834	1,907.200	1,835.680	1,835.680	1,835.680	1,835.680	1,835.680	1,835.680	1,835.680	1,835.680
Electricity revenue	2	10.70	25.96	47.80	76.09	107.38	138.46	173.10	211.29	253.04
Foregone fuel tax (30%, from 2026)	0	18	109	178.72	268.50	383.42	453.60	523.45	593.31	663.16
Net fiscal impact	(833)	(1,914.45)	(1,918.93)	(1,966.60)	(2,028.09)	(2,111.72)	(2,150.82)	(2,186.03)	(2,217.70)	(2,245.80)
PV net fiscal impact	(833)	(1,740.40)	(1,585.89)	(1,477.53)	(1,385.21)	(1,311.21)	(1,214.08)	(1,121.78)	(1,034.57)	(952.44)
Cumulative PV fiscal	(833)	(2,573.03)	(4,158.92)	(5,636.45)	(7,021.66)	(8,332.87)	(9,546.96)	(10,668.74)	(11,703.31)	(12,655.75)
Forex Impact ($ Million)										
Fuel liters avoided per EV/year (L)	2400	2400	2400	2400	2400	2400	2400	2400	2400	2400
Fuel import savings	48.72	179.40	364.03	595.73	895.01	1,278.05	1,512.00	1,744.85	1,977.70	2,210.54
EV import premium vs ICE	(245.00)	(560.00)	(539.00)	(539.00)	(539.00)	(539.00)	(539.00)	(539.00)	(539.00)	(539.00)
Net forex gain	(196.28)	(380.60)	(174.97)	56.73	356.01	739.05	973.00	1,205.85	1,438.70	1,671.54
PV net forex gain	(196.28)	(346.00)	(144.60)	42.62	243.16	458.89	549.23	618.79	671.16	708.90
Cumulative PV forex gain	(196)	(542)	(687)	(644)	(401)	58	607	1,226	1,897	2,606

Summary (2024-2033, NPV at 10% discount)	
Total fleet size (Year 10)	731,000
NPV fiscal sacrifice ($ Million)	(12,655.75)
NPV net forex gain ($ Million)	2,605.87
Net benefit ($ Million)	(10,050)
Benefit-to-cost ratio	0.2:1

The policy achieves forex break-even in 2029 (Year 6), when cumulative fuel savings begin to exceed cumulative import premiums and cumiulative PV forex gain turns positive. By 2033, annual net forex gains reach $709 million, and the present value of a cumulative forex gain is $2,606 million (NPV). However, this only covers 20% of the fiscal sacrifice.

Figure 1 shows the cumulative net fiscal impact of Ethiopia's EV incentive policy from 2024 to 2033, discounted at 10%. The increasing fiscal burden demonstrates that the substantial tax revenue should be sacrificed to sustain the policy. Beginning at $833 million in 2024, cumulative losses reach to $12,656 million by 2033 as foregone import duties, fuel taxes, and excise revenues accumulate over the growing fleet. The trajectory after 2026 reflects the introduction of a 30% fuel tax, with foregone revenue growing from $179 million in 2027 to $663 million by 2033.

Figure 1. Cumulative Net Fiscal Impacts (NPV at 10% Discount)

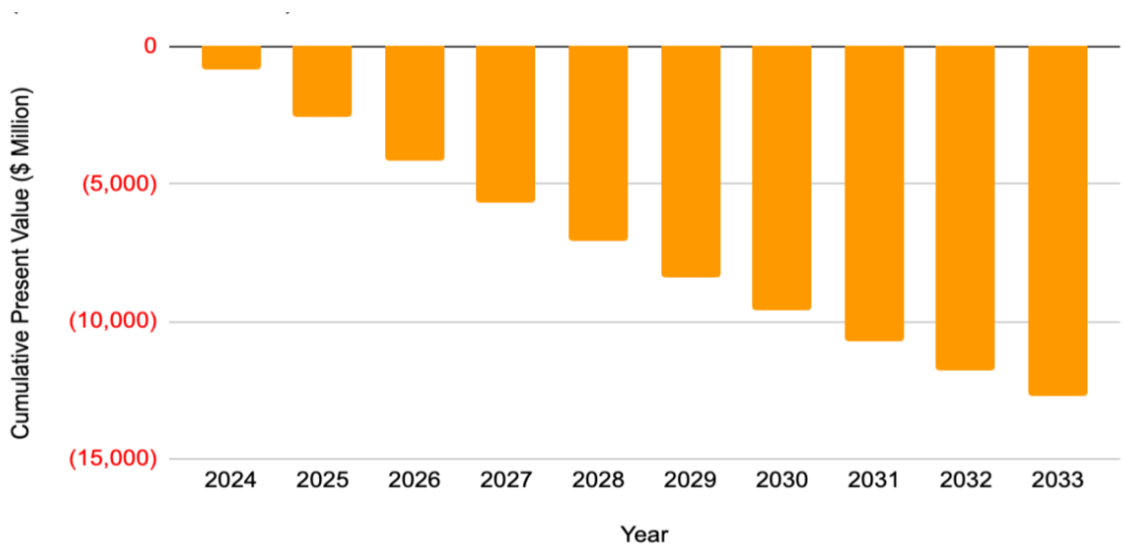
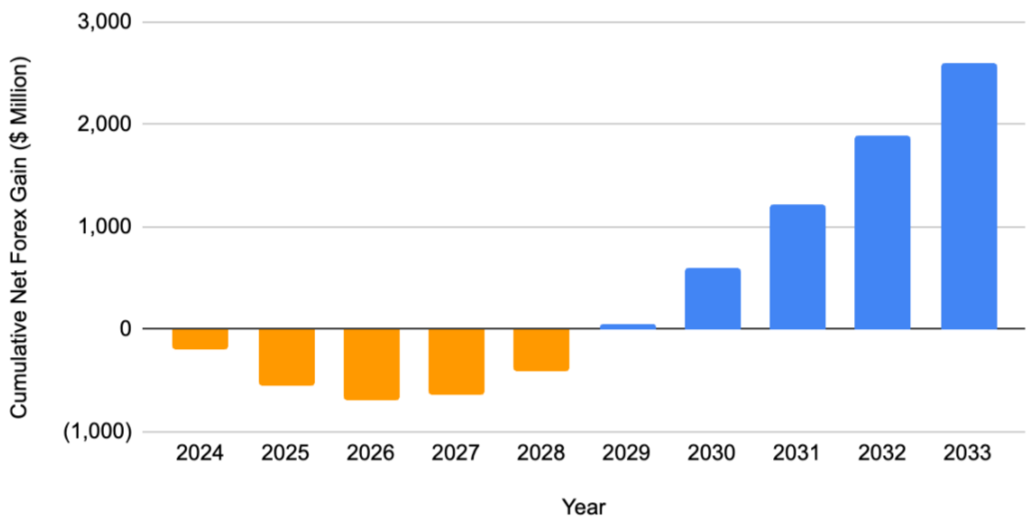


Figure 2 presents the cumulative net foreign exchange impact, discounted at 10%. It illustrates the policy's delayed forex benefits. Cumulative forex impacts remain negative from 2024 to 2028. The break-even point occurs in 2029 after five years of EV policy, where cumulative fuel savings offset accumulated EV import costs. From 2029 onward, forex gains accelerate, reaching to $2,606 million by 2033 as the cumulative fleet of 731,000 vehicles avoids approximately $2.2 billion in annual fuel imports. The color transition from orange (negative) to blue (positive) shows the policy's temporal challenge: Ethiopia must finance import costs for five years—worsening its binding economic constraint during a period of acute foreign currency shortage—before achieving net forex benefits.

Figure 2. Cumulative Foreign Exchange Savings (NPV at 10% Discount)



Under conventional valuation, the policy is not economically viable regarding the net loss. However, the policy is effective in mitigating exchange shortage and gaining foreign exchange.

IV. Limitations

There are several limitations to this analysis. In economic impacts, the analysis does not consider any infrastructure costs–such as charging stations, grid and distribution network expansion, and used-car dump service. The CIF costs of EVs and ICEs do not account for potential variations in the future.

The model does not include confidence intervals, providing only single estimates. Sensitivity analysis of key parameters such as import taxes and discount rate with low, base, and high scenarios would be valuable for further exploration.

Notably, this analysis excludes several benefit categories. Economic impacts including employment generation in EV maintenance and charging infrastructure, which have potential for domestic technology development and industrial capacity building, are not quantified. The environmental and public health benefits of CO_2 emissions reduction and improved air quality are also not monetized. Energy security gains from reduced petroleum import dependence are not valued economically. A comprehensive valuation of these factors would likely improve the benefit-cost ratio, though there are challenges to quantifying them.

DISCUSSIONS

In this section, I want to highlight other important factors that determine the policy's successful implementation. In addition to financial viability, there are several practical challenges toward Ethiopia's EV transition, such as infrastructural and socioeconomic barriers. Understanding these would help see the energy/climate policy through dimensional perspectives.

I. Energy Access Constraints

One of the biggest challenges toward EV policy is energy access in Ethiopia. Electricity must be available to use EVs, which requires an accessible national grid. However, only half of its 126 million people in Ethiopia have access to electricity. Even among those who have access, only 20% of households receive electricity for at least 23 hours a day, and only a third are connected to the national grid (Harter, 2025). Further, grid coverage is concentrated in urban areas, leaving rural areas potentially excluded from the EV transition.

II. Charging Infrastructure Deficit

The shortage of charging infrastructure is another challenge. As of early 2025, Ethiopia has just over 100 charging stations compared with 21,600 in London, and nearly all Ethiopian stations are concentrated in Addis Ababa (Harter, 2025). This infrastructure gap creates several adoption barriers. First, EV ownership becomes impractical outside the capital, limiting the addressable market to urban Addis Ababa residents. Second, frequent power outages in rural areas make reliable charging impossible even where stations exist, restricting EVs to short urban commutes. Lastly, the government's fiscal constraints—in the $12,722 million revenue sacrifice in this analysis—allow only limited public resources for charging infrastructure investment. This infrastructure deficit thus makes consumers hesitate to purchase EVs without charging access, while investors hesitate to build charging networks without a mass of EV owners. This would result in slower fleet growth, reducing foreign exchange savings while fiscal costs continue to accumulate.

III. High Upfront Costs of EVs

Despite innovative tax exemptions, EVs remain expensive for the average Ethiopian consumer. A BYD model costs approximately 2.2 million Ethiopian birr (£11,000) in a country where doctors earn an average of 12,000 Ethiopian birr (£60) per month (Harter, 2025). While ICE vehicles also became expensive due to the soaring import levies, the upfront cost of EVs is still a huge barrier. Even electric two-wheelers, considered more affordable alternatives, face constraints. A World Bank assessment characterized the case for two-wheeler EVs in Ethiopia as "very marginal", given a capital cost premium exceeding 25 percent over conventional motorcycles (World Bank, 2023). This is equivalent to about 5 percent of gross national income per capita (World Bank, 2023). As a result, consumers may prefer used ICE vehicles rather than electric alternatives. This consumer preference pattern could slow EV adoption, thereby limiting foreign exchange savings.

IV. Lack of Skilled Labor

Both the United Nations Economic Commission for Africa (UNECA) and Ethiopia's Ministry of Transport (MOT) have identified the lack of skilled labor and limited public understanding as major hindrances to implementation. They advocate for a national training and awareness-building strategy to address this gap. The International Motor Vehicle Inspection Committee (CITA) has highlighted the need for EV inspection and service experts to address EV-specific safety and maintenance risks (CITA, 2022). This shortage of technical expertise not only hinders consumers from purchasing and using EVs, but also raises concerns about long-term vehicle maintenance and safety standards.

CONCLUSION

This case study examines Ethiopia's electric vehicle incentive policy through a cost-benefit analysis of a fiscal-forex trade-off. It aims to identify the economic viability of the policy by quantifying the immediate fiscal sacrifice of tax revenues and the long-term forex saving gains driven by reduced fuel imports. The analysis results in challenges to the policy's economic viability, and the main findings of the analysis are as follows. The policy generates substantial fiscal sacrifice. Cumulative tax revenue losses reach $12,722 million in present value terms over the 2024-2033 period. This is driven by import duty exemptions, foregone fuel tax revenues, and excise revenue losses. While the policy delivers foreign exchange savings of $2,606 million in cumulative present value by avoiding fuel imports, these gains cover only 20 percent of fiscal costs, and the break-even occurs in 2029, only after five years when the policy begins. This late break-even makes a temporal lag: fiscal sacrifice costs continue to accumulate, while forex savings occur after a five-year payback period. This implies that the government must bear the fiscal burdens for five years before forex exchange occurs. As a result, it incurs a net economic loss of $10,116 million, representing an unsustainable allocation of resources.

However, from the perspective of forex savings, the analysis demonstrates that the EV policy achieves economic viability as a mechanism to address Ethiopia's acute forex scarcity. This indicates that the national EV transition strategy prioritizes long-term foreign exchange savings over immediate tax revenue from import duties. Thus, policymakers must determine if the value of these forex savings justify the substantial fiscal sacrifice required in the near term.

Future research should incorporate additional factors to enhance the robustness of the analysis. Conducting sensitivity analyses in varied discount rates, alternative fuel price trajectories, and diverse combinations of import duty adoption would suggest more realistic outcomes. Monetizing the social effects of environmental externalities, job creation, and industry development would provide a more comprehensive assessment of the policy. While the study has limitations, it succeeds in providing a quantitative foundation for assessing the electric vehicle transition in Ethiopia. Although the transition to EVs delivers foreign exchange advantages, the accompanying fiscal burdens challenge its economic justification and require a re-evaluation of Ethiopia's development priorities.

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Nigeria’s Energy Transition Plan: Feasible or Fiction?

Ozioma Ozigbo

Master of Engineering, Climate & Sustainability Engineering, Pratt School of Engineering, Duke University

INTRODUCTION: THE BLACK SOOT CRISIS

Most Nigerians did not become environmental advocates by choice; they were pushed into it.

In 2016, the city of Port Harcourt in Rivers State, Nigeria, experienced what is now known as the *black soot crisis*. For months, a strange black dust blanketed the air of the nation’s oil capital. Residents inhaled it, ingested it, and watched their palms turn black after touching everyday surfaces. Homes were mopped and dusted multiple times a day, only for soot to return by morning. The air was visibly polluted, but they had no choice but to breathe (Kalu, 2018).

Black soot is a fine mass of impure carbon particles produced by the incomplete combustion of fossil fuels, biomass, and other organic materials (UNDRR, 2023). According to the U.S. Environmental Protection Agency (EPA), black soot is one of the most dangerous forms of air pollution due to its ability to penetrate deep into the lungs and bloodstream (EPA, 2024). While considered a short-lived climate pollutant, its impacts on human health are long-lasting, with links to respiratory disease, cardiovascular illness, and cancer (Owhor et al., 2023). In Nigeria, the crisis stemmed from a convergence of issues: artisanal oil bunkering, illegal refining, gas flaring, and the open-air burning of confiscated crude by security forces (Kalu, 2018). Following this crisis, Port-Harcourt residents protested the increased deterioration of ambient air quality. Soon after, the Ministry of Environment declared the air pollution an “Emergency situation” and the Governor of Rivers State, Nyesom Wike, set up a Task Force to investigate the source of the pollution and find a resolution (Yakubu, 2017). Years later, Nigerians are still dealing with the effects of the crisis (Akinwotu, 2022).

Although dialogue on energy and the environment in Nigeria began long ago, for many, this crisis marked a turning point (Myers, 2023). What some call an energy transition and is perhaps more accurately described, in Nigeria’s case, as an energy revolution (Ibezim-Ohaeri, 2025).

Figure 1. Orji, S. (2020) Black soot still plagues the residents of the Niger Delta

NIGERIA'S ENERGY CONTEXT

Any discussion of energy transition in Nigeria must begin with the country's structural realities. Nigeria is Africa's most populous nation, with about 237 million people and one of the continent's largest economies (Statista, 2024). Its growth is powered by sectors such as oil and gas, telecommunications, technology, entertainment, and real estate. Yet only about 61% of Nigerians have access to electricity, leaving roughly 87 million people without power – the largest energy access deficit in the world. Even among those connected to the grid, electricity supply averages only 6 hours per day (Pelz et al., 2023). This unreliability has made diesel and petrol generators a normalized part of daily life, embedding fossil fuel dependence at the household and business level (Statista, 2023). For example, in the city of Lagos, the nation's economic and financial hub, there are about 4.5 million fossil fuel generator sets (gensets) being used. These produce total estimated annual emissions of 39 million tonnes of CO2 equivalent (tCO2e) – more than the genset emissions of Togo, Rwanda and Gabon combined. (SEforALL, 2024a)

At the macroeconomic level, oil accounts for approximately 95% of Nigeria's foreign exchange earnings. Current expansion plans aim to increase crude production to 3 million barrels per day by 2030, even as oil extraction continues to drive environmental degradation, habitat loss, community displacement, and public health risks (Addeh et al., 2026). It is worth noting that while Nigeria is a leading African oil producer, its citizens have seen fewer economic benefits than those in other oil-rich nations. For decades, the country suffered from a refining paradox where its state-owned refineries sat inactive, forcing it to export crude and import expensive refined fuel (BBC, 2024). However, with the Dangote Refinery in Nigeria; the world's largest single-train refinery reaching full capacity in early 2026, Nigeria has transitioned to refining its own oil domestically.

Despite this shift, citizens still pay a premium at the pump because fuel prices are now tied to global market rates rather than government-subsidized local prices (Thomas, 2024). This dynamic makes the energy transition look increasingly compelling if it can deliver lower energy costs. Nigeria also remains one of the world's leading gas-flaring nations, wasting significant natural gas resources while contributing heavily to greenhouse gas emissions (IEA, 2023). Although the Nigeria Gas Flare Commercialization Programme (NGFCP), launched in 2016, aimed to end routine flaring by 2020, that target was not achieved (World Bank, 2023).

CURRENT ENERGY CONSUMPTION IN NIGERIA

The figures below show Nigeria's total energy consumption according to the International Energy Agency (IEA). This profile reveals a country that is both fossil-fuel dependent and heavily reliant on traditional biomass, underscoring the complexity of any transition pathway.

Figure 2. Total Energy Supply, Nigeria 2023

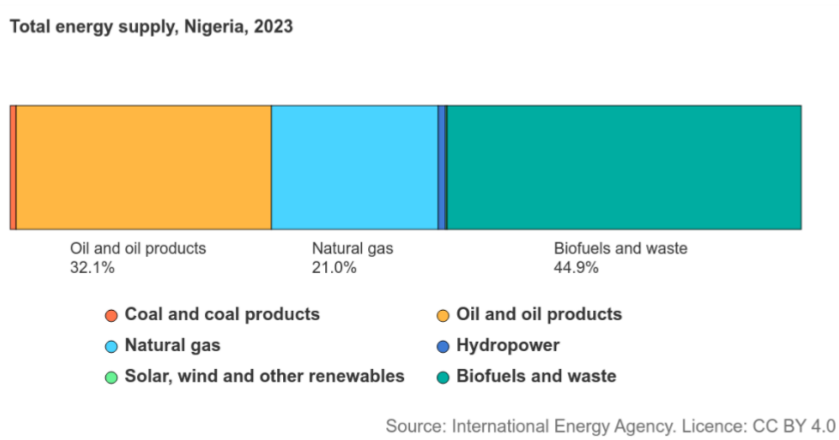
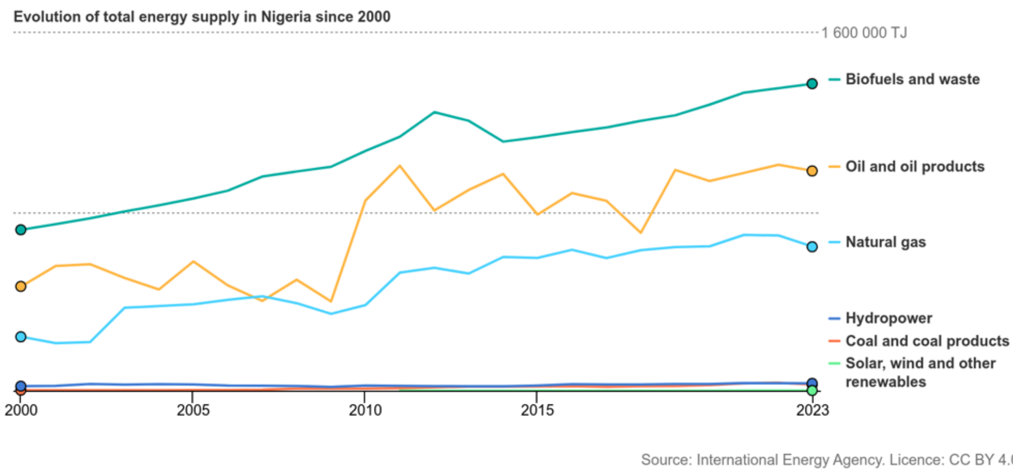


Figure 3. Evolution of Total Energy Supply in Nigeria since 2000



Nigeria is also a country deeply rooted in communal systems. Across more than 250 ethnic groups, local governance structures, collective decision-making, and strong community networks remain central to social and economic life (Dukeh, 2025). In particular, the breakdown of community ties due to environmental neglect and perceived exclusion has historically led to systemic sabotage and oil theft, costing the nation billions in lost revenue (Andrew & Salifu, 2020). For a successful energy transition, Nigeria must leverage the Host Communities Development Trusts (HCDTs) mandated by the Petroleum Industry Act (PIA) 2021 to ensure that local populations are economic stakeholders in new green infrastructure, rather than victims of its implementation (Oladeji et al., 2023). These social dynamics are critical to understanding how energy transition policies are likely to succeed – or fail – in practice.

NIGERIA'S ENERGY TRANSITION PLAN

At COP26, Nigeria formally unveiled its Energy Transition Plan (ETP), setting a target of achieving carbon neutrality by 2060. The plan is framed not only as a climate strategy but as a national development pathway. It rests on six interconnected pillars: improving energy access, reducing poverty, expanding modern energy use, preserving jobs, enabling a sustainable transition, and strengthening legislation. Together, these pillars signal an effort to align decarbonization with economic growth and social stability – an especially delicate balance in a country where energy access remains limited and fossil fuels underpin the economy (Federal Government of Nigeria [FGN], 2022).

The plan identifies several areas of opportunity across key sectors. In the power sector, the ETP envisions a gradual reduction in reliance on diesel generators, which currently serve as a costly and polluting backup for millions of households and businesses. In the near term, natural gas is positioned as a transition fuel to stabilize electricity supply, while renewable energy is expected to play an expanding role as infrastructure and investment grow (FGN, 2022). This dual approach reflects the government's attempt to address immediate energy reliability needs while laying the groundwork for a lower-carbon grid.

In the transportation sector, the plan anticipates the adoption of electric vehicles as a pathway to reduce emissions from Nigeria's growing mobility sector (FGN, 2022). Recent case studies have demonstrated deployment models of public mass transit solutions within the nation as it offers an opportunity to mitigate higher transport costs, serves as a viable alternative to passenger cars and enables significant carbon emissions reductions (SEforALL, 2024b). In 2023, the Vice President of Nigeria, Kashim Shettima, officially unveiled an electric car that has been assembled and designed within the country. This came in the wake of the National Economic Council's endorsement of the National Automotive Design and Development Council (NADDC) initiative to initiate large-scale production of electric vehicles in Nigeria (SEforALL, 2024b). Although still nascent, this signals recognition that transport emissions will rise alongside urbanization and economic development unless cleaner alternatives are introduced early.

Within the oil and gas sector, the ETP targets emissions reductions through decreased gas flaring and improved efficiency in upstream operations. Given Nigeria's status as a major oil and gas producer, these measures represent an effort to reduce the carbon intensity of ongoing fossil fuel activities, even as the broader energy system gradually diversifies.

Clean cooking is another priority area. A significant portion of Nigerian households still rely on traditional fuels such as firewood and kerosene, with serious implications for public health, where about 128,000 people died in Nigeria in 2019 from household air pollution related to these fuels (Roche et al., 2024). The ETP promotes a shift toward liquefied petroleum gas (LPG), biogas-based systems, and electric cooking as pathways to modernize household energy use and reduce exposure to indoor air pollution (FGN, 2022).

The plan also addresses industrial decarbonization, particularly in emissions-intensive industries such as cement and ammonia production (FGN, 2022). As Nigeria continues to urbanize and industrialize, these sectors are expected to grow, making early attention to efficiency and cleaner processes an important component of long-term emissions management.

POLICY AND EARLY ACTIONS

Nigeria has introduced a range of enabling policies, including a Climate Change Act to guide national climate governance, feed-in tariffs to incentivize renewable energy investment, and tax incentives for independent power producers (FGN, 2022). The 2023 Electricity Act decentralized the power sector, opening new pathways for state-level electricity markets and mini-grid expansion. The Act empowers Nigeria's 36 states to license, regulate, and manage their own independent electricity markets for generation, transmission, and distribution within their boundaries. Crucially, it prioritizes the energy transition by mandating the integration of renewable energy into the national mix through incentives like feed-in tariffs, tax breaks, and net-metering provisions (UNCTAD, 2023). Methane reduction guidelines and NGFCP permitting processes further signal attempts to curb emissions in the oil and gas sector (Climate Action Tracker, 2023). Currently, Nigeria ranks 61st out of 120 countries on the Energy Transition Index (moving from 109 in 2016), driven by improvements in financial investments and infrastructure (World Economic Forum, 2025).

CHALLENGES TO NIGERIA'S ENERGY TRANSITION PLAN

Despite the opportunities outlined above, the plan faces substantial structural challenges. Affordability remains a central barrier. With over 40% of Nigerians living in poverty, the upfront costs associated with electric vehicles, clean cookstoves, and other modern energy technologies place these solutions beyond the reach of many households. For example, the upfront cost of small to medium solar PV systems ranges from ₦1 million to ₦5 million, representing 148% to 480% of the average annual income (Okafor, 2025). Without targeted financial mechanisms, the benefits of transition risk being captured primarily by higher-income groups (Energy for Growth Hub, 2023).

The plan's reliance on natural gas as a transition fuel raises concerns about long-term carbon lock-in. Gas infrastructure typically has long operational lifetimes, and large-scale investments made today could commit Nigeria to continued fossil fuel dependence well into the future, well past any reasonable net-zero pathway, potentially undermining efforts to meet long-term climate goals (Energy for Growth Hub, 2023).

Human capacity presents another significant constraint. Implementing a low-carbon transition at scale requires specialized technical skills, deep institutional knowledge, and large-scale workforce retraining. Current skills gaps could slow deployment of new technologies and limit Nigeria's ability to fully capture the economic opportunities associated with the transition (FGN, 2022).

Finally, financing looms as the most significant obstacle. The ETP is estimated to require approximately $500 billion in investment, a figure that far exceeds current levels of climate and energy finance of about $2.5 billion flowing into Nigeria (Stout, 2025). Limited private sector engagement, investor uncertainty, and perceived country risk further complicate efforts to mobilize the necessary capital at scale (FGN, 2022).

Together, these challenges underscore a central tension within Nigeria's Energy Transition Plan: it is ambitious in scope and broad in vision, but its success will depend on whether economic, institutional, and social constraints can be addressed with the same level of urgency as emissions reductions.

ENERGY SECURITY VS. ENERGY TRANSITION

In Nigeria, the defining energy question is simple: *Why is there no light?*

This "million-naira" question has spanned generations. Explanations often point to chronic grid inefficiencies, weak infrastructure, planning failures, and financial constraints – conditions that have left millions dependent on self-generation. For these households and businesses, energy security (reliable and affordable electricity) is more immediate than decarbonization.

This creates a central tension: energy transition focuses on cleaner systems, while energy security demands stable power now. If transition policies do not first address reliability and affordability, they risk being perceived as detached from everyday realities. A transition that removes diesel generators without providing dependable alternatives would not be progress – it would be deprivation.

COMMUNITY INNOVATION AND THE PRINCIPLE OF SUBSIDIARITY

The principle of subsidiarity holds that social and political challenges should be addressed at the most immediate or local level capable of resolving them, rather than being delegated upward to distant central authorities (UN DESA, 2025). In Nigeria's energy sector, this principle has re-emerged less as a deliberate governance reform and more as a practical response to persistent federal inefficiencies. Decades of limited progress in expanding reliable electricity access have created space for localized actors to step in, not only to fill gaps, but to redefine how energy solutions are designed and delivered.

In the wake of environmental degradation and chronic energy shortages, community-driven and private-sector initiatives have often advanced more rapidly than large-scale federal interventions. Companies such as Lumos, Arnergy, and Green Village Electricity (GVE) have deployed distributed solar systems and mini-grids that deliver both improved energy access and lower-emission supply. In 2025, about 200 mini-grids were deployed by Nigeria's rural electrification agency (REA, 2025). These decentralized models are particularly significant because they address two of Nigeria's most pressing challenges simultaneously: energy reliability and environmental sustainability. By tailoring systems to local demand patterns and income levels, they demonstrate that energy transition and energy security need not be competing objectives.

Beyond individual projects, the broader ecosystem of Nigerian energy startups reflects a meaningful shift in where innovation is occurring. The private energy sector has become a dynamic space where affordability, access, and sustainability are pursued together rather than in isolation. This evolution suggests that the foundations of a just energy transition in Nigeria may be emerging from the bottom up, shaped by community needs and entrepreneurial adaptation, rather than solely through centralized planning.

Re-centering subsidiarity in this way does not eliminate the need for federal policy, regulation, or financing. Instead, it highlights the importance of governance structures, such as those established by the 2023 Electricity Act, that reduce barriers to small-scale deployment and integrate community-led systems into national planning. In this sense, subsidiarity becomes not only a principle of governance but a practical framework for aligning Nigeria's development realities with its energy transition ambitions.

CONCLUSION: FEASIBLE, BUT CONDITIONAL

Nigeria's Energy Transition Plan is not fiction, but its feasibility depends on whether it can reconcile ambition with lived reality. This includes but is not limited to the multi-billion-dollar funding gap, high capital costs of renewable energy technologies, grid modernization requirements, human capital, and policy stability. The bottom-up approach to deploying renewable energy with Lumos and Arnergy, for example, presents a reduced cost model compared to the conventional pathway. This also creates millions of job opportunities, and strong community engagement leading to reduced local political risk (Tambari et al., 2020). A just transition in Nigeria must protect workers in fossil fuel-dependent regions, prioritize universal energy access, and empower communities as active participants rather than passive beneficiaries.

For some Nigerians, the ETP represents hope: hope that energy poverty, pollution, and economic vulnerability can be addressed together. For others, it is a sobering reminder of promises long made and rarely fulfilled. Whether this plan becomes a transformative roadmap or another well-written document collecting dust (or soot) will depend on implementation, accountability, and an unwavering focus on justice.

Nigeria's energy future cannot be built on targets alone. It must be built on the shared determination of its people – by their communities, and for generations yet to come.

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Powering Peace: Unpacking The Humanitarian Energy Gap In Northeastern Nigeria's Displacement Settings

Madeline Sachtler

Master of Public Policy (MPP '26), Sanford School of Public Policy, Duke University

STRUCTURAL BLIND SPOTS IN NATIONAL ENERGY POLICY: THE CASE OF DISPLACED COMMUNITIES IN NORTHEASTERN NIGERIA

Nigeria operates a centralized energy system and despite its substantial primary energy resources such as oil and gas, abundant sunlight and significant hydropower, energy poverty remains a widespread phenomenon amongst its 230 million citizens. In recent years, the Federal Government of Nigeria (FGN) has taken steps to diversify its energy sources and promote renewable energy through various policies and legislative initiatives. The energy sector faces numerous challenges arising from poor planning, weak implementation, and limited expansion efforts – all compounded by rapidly growing demand driven by the country's massive population growth over the last two decades (Diji, 2013).

To address the country's deepening energy poverty, the African Development Bank, in partnership with the Africa Growing Together Fund, has launched an energy access initiative implemented through the Rural Electrification Agency, with the aim of accelerating reliable, decentralized power delivery to underserved communities ("Nigeria - Nigeria Electrification Project," n.d.). The Nigerian Electrification Project (NEP, 2018–2026) is a nationwide initiative that supports the FGN's goal of expanding energy access in alignment with the country's national development agenda. The project will provide electricity access to households, small-to-medium-sized enterprises (SMEs), and public institutions in a least-cost and timely manner through off-grid and mini-grid solutions ("Nigeria - Nigeria Electrification Project," n.d.). This expansion of reliable electricity access is expected to stimulate local economic activity, enhance SME productivity, and create conditions conducive to industrial growth in underserved regions.

The creation of the NEP catalyzed the establishment and growth of an off-grid and mini-grid industry in Nigeria through grant subsidy-based agreements. Building on this foundation, the FGN, with support from the World Bank, aims to scale up the impact of the NEP through the Distributed Access through Renewable Energy Scale-up (DARES) project, furthering achievements in national energy access. The project aims to deploy 465 MW of decentralized renewable energy through 1,225 mini-grids and over 1 million stand-alone solar systems, expanding access to more than 3.2 million households, including 525,731 female-headed households (Rural Electrification Agency, 2024). It will also power 236,986 SMEs, driving economic growth and improving the lives of an estimated 17.5 million people (Shrestha & Obi, 2022).

Beyond its direct targets, DARES has emerged as a central platform for coordinating energy access interventions among development partners, promoting efficient resource use, and strengthening the overall energy access ecosystem. Ultimately, this renewables-focused donor commitment is intended to help steer the country away from natural gas dependence and toward off-grid solar technology, particularly in response to persistent concerns about the reliability of the national grid. While decentralized energy systems are a critical strategy for enhancing energy access and resilience, their deployment has tended to concentrate in commercially viable regions with stronger infrastructure and better access to finance. This initiative is unlikely to be different, as project sites must undergo risk screening and categorization under the World Bank's Environmental and Social Framework, potentially discouraging implementation in institutionally weaker regions (Rural Electrification Agency, 2024). This creates an uneven distribution that is reinforced by the project approval process itself, which places location choice in developers' hands and subjects higher-risk sites to more extensive safeguards and assessments. High-risk projects – such as those involving significant physical or economic displacement, labor and occupational safety risks, or a large migrant workforce – require several Environmental and Social Impact Assessments, often followed by a Livelihood Restoration Plan (Lahn, 2021).

The northeast region presents perhaps Nigeria's most complex energy challenge where issues of displacement, insurgency, desertification and extreme poverty classify most of the region as high-risk (Johnson, 2025). Under such conditions, revenue uncertainty and security risks incentivize developers to adopt more risk-averse investment strategies, particularly in project site selection, as they depend on predictable demand and stable policy environments for a guaranteed return on investment (Grafham et al., 2022). Licensing data reveals that energy projects are instead concentrated in the southwest and southeast regions, receiving 75% of licensed capacity in recent years (Daggash, 2025). These regions have comparatively higher levels of energy access already, reinforcing existing regional disparities.

Although humanitarian actors maintain a significant presence in the northeast, coordination with development institutions on long-term energy planning remains limited. Research has shown that national host government policy is crucial for creating an ecosystem that enables collaboration between development and humanitarian actors in the implementation of clean energy objectives in displacement settings (UNHCR, 2025). While development agencies tend to approach these issues through careful research, in-depth analysis and stakeholder consultations, humanitarian agencies rarely have the time, resources or technical expertise to engage with them as thoroughly (UNHCR, 2025).

According to UN Refugee Agency's (UNHCR) 2024 Annual Report, the FGN as well as the private sector are working to implement protection-based interventions aimed at improving the resilience of forcibly displaced populations in the northeast UNHCR, 2025). However, these efforts have failed to include expanded energy provision, despite the FGN's large-scale collaboration with the World Bank through the DARES project. In the absence of targeted interventions to assess and address the energy needs of displaced settings in the northeast, the region risks prolonged electricity exclusion, constraining economic development and failing to address a key driver of regional conflict.

A CRISIS IN THE LAKE CHAD BASIN

Energy poverty and regional instability have long affected northeast Nigeria, with Borno State recording the highest rates of energy deprivation in the country. Despite the region's high potential to benefit from initiatives such as the DARES project, several structural and security challenges continue to impede meaningful progress. These challenges stem from a combination of government mismanagement and underdeveloped infrastructure, compounded by persistent security concerns linked to ongoing armed conflict. Over the past 15 years, the region has been the site to hostilities between the Nigerian government and jihadist military groups, creating unstable and unsafe living and working conditions. In addition to the impacts of the protracted insurgency, the continued recession of Lake Chad, especially along the Nigerian shoreline, has exacerbated food shortages and water insecurity, further fueling violence and social unrest. Together these compounding pressures have resulted in widespread displacement, disrupting livelihoods and deepening humanitarian crisis across the broader Lake Chad Basin.

Conditions in the region have deteriorated further amid broader national economic decline, with inflation reaching 34%, fueling economic grievances within affected communities (UNHCR, 2025). Additionally, the September 2024 floods in the northeast compounded these pressures, causing extensive damage to public infrastructure and affecting an estimated 419,000 non-displaced residents in Borno, 49,000 in Adamawa, and 15,000 in Yobe (UNHCR, 2025). In Maiduguri alone, the aftermath left just one displacement camp remaining operational, hosting approximately 36,000 flood-affected residents (UNHCR, 2025). As of 2025, mounting instability has displaced approximately 3.6 million people across the entire northeastern region, fueling tensions between internally displaced persons (IDPs) and host communities as competition for resources intensifies (International Organization for Migration, 2025).

This situation is unlikely to improve in the near future, particularly amid a widening humanitarian funding shortage that is reshaping the capacity of international response. The 2025 Global Humanitarian Assistance (GHA) report detailed funding reductions across the sector, estimating that public funding available for humanitarian action could contract by 34% to 45% (Pearson et al., 2025). This shortfall is reflected in the United Nations Office for the Coordination of Humanitarian Affairs' (OCHA) November 2025 report, which found that only USD 836 million – 25%, of the required humanitarian response budget for the Lake Chad Basin – had been secured to address the needs of the 10.4 million people requiring assistance (UN Office for the Coordination of Humanitarian Affairs, 2025).

Electricity provision across the northeast is largely dependent on stand-alone diesel generators, a model that is appropriate for short-term humanitarian responses but one that typically restricts energy use to the most essential services. In the absence of reliable grid power, generators are necessary for pumping water, operating offices, maintaining temperature-controlled storage of food and equipment in warehouses, and running medical and educational facilities (Lehne et al., 2016). It is widely acknowledged that most diesel generators in humanitarian operations are run inefficiently, which means that more units than necessary are required to meet overall energy demand (International Energy Agency et al., 2018). This operational inefficiency significantly increases fuel consumption and associated maintenance costs. Consequently, it places mounting financial pressure on international organizations operating in protracted emergency contexts, such as the Lake Chad Basin crisis, where continued fuel procurement remains necessary to sustain operations.

BRIDGING THE HUMANITARIAN–DEVELOPMENT ENERGY GAP

The high costs of the current humanitarian energy system do not inherently constitute a problem. The more important question is whether energy is being used wastefully, and whether the same or higher demand for energy services could be met at lower cost and with lower environmental impact (Grafham & Lahn, 2018). Some argue that energy infrastructure represents a long-term investment and is therefore inappropriate in the context of immediate emergency response (Lehne et al., 2016). However, solar power has been successfully integrated into refugee camps in several contexts, offering a model for future deployment. In May 2017, UNHCR commissioned a 2 MW solar photovoltaic (PV) plant at Azraq camp in Jordan; the following November, a 12.9 MW plant funded by the German government at Zaatari camp (Grafham & Lahn, 2018). These have enabled UNHCR to offset increased household electricity consumption through net metering, reducing grid electricity costs by the amount of power generated by the solar plants and fed back into the grid (Grafham & Lahn, 2018).

The integration of solar power in these settings was not the only revolutionary innovation introduced. Both cases involved the use of humanitarian aid funds to build “legacy assets,” which are meant to remain functional beyond the refugee-hosting period (Grafham & Lahn, 2018). Earlier research on energy provision in displacement settings has focused primarily on implementation challenges related to energy business models, citing low projected energy consumption, limited ability to pay for services, and insufficient incentives for private-sector investment (Gunning, 2014). What this body of research often overlooks, however, is that energy provision in displacement settings extends beyond IDP households alone. Electricity also supports humanitarian service delivery and flows to surrounding host communities, thereby contributing to broader regional economic development objectives. The installations in Azraq and Zaatari also pioneered a new approach to project financing. The IKEA Foundation funded the entire EUR 8.75 million capital cost of the Azraq solar farm project, partly through its profits from LED lightbulb sales (Grafham & Lahn, 2018). It has been saving UNHCR USD 2 million each year since being upgraded to 3.5 MW in September 2018 through additional funding from the Saudi Development Fund (Grafham & Lahn, 2018). The Zaatari installation is expected to reduce annual CO2 emissions by 13,000 tons while saving UNHCR around USD 5.5 million per year (Grafham & Lahn, 2018).

However, Nigeria and Jordan are vastly different contexts, each facing distinct displacement crises. Jordan is accommodating Syrian refugees, who have crossed an international border and are protected under international refugee law. Displaced Nigerians remain within their own country as IDPs where their protection depends largely on their own government’s capacity and willingness to respond. Refugees are not necessarily expected to permanently rebuild their lives in a host country, as voluntary repatriation, resettlement, or return remain possible long-term solutions. In contrast, IDPs must pursue recovery and reintegration within their own country. Thus, from the perspective of international organizations, supporting resolution in displacement settings requires solutions that promote self-reliance and enable a transition from immediate life-saving assistance to longer-term development pathways.

As humanitarian organizations continue to operate in the northeast region, they should pursue more innovative solutions to move beyond the “diesel-first” mindset that currently dominates energy provision. Doing so requires integrating energy planning for displaced populations into the broader development priorities of host communities. At the same time, while solar energy systems offer significant long-term benefits, they are not suitable for immediate deployment in active crisis contexts, indicating that diesel generators should not be abandoned altogether. A more effective approach would be to complement existing generators with a solar mini-grid, deploying a hybrid system that increases both electricity supply and operational efficiency (Beath et al., 2023). Hybrid solar PV–diesel systems offer a flexible alternative to both grid extension and diesel-only generation, integrating renewable and conventional power sources within a single system. These systems can be configured in two ways:

- In a load-following configuration, generators operate only when solar generation is insufficient, providing electricity on demand.
- A cycle-charging configuration, by contrast, uses generators strategically to meet demand while also charging batteries.

The latter option allows for higher-capacity operations, increased efficiency, and reduced fuel consumption per unit of output, thereby reducing both the number of generators needed and the associated maintenance cost (Beath et al., 2023).

Though hybrid mini-grids offer the potential to address growing energy needs in displacement settings, their deployment remains limited, and further research is needed to evaluate options for their implementation and their associated financial and environmental impacts (Beath et al., 2023). Appropriately sizing the components of a hybrid mini-grid is important for both cost efficiency and ensuring system reliability (Blechinger et al., 2016). Energy accounting practices remain notoriously underdeveloped in humanitarian organizations, with diesel consumption often going unmonitored, unregulated, and unadjusted to reflect actual camp needs and usage (Beath et al., 2023). The absence of robust monitoring and evaluation frameworks in energy deployment discourages private-sector participation, particularly when organizations demonstrate insufficient attention to cost-efficiency.

If project managers implement strict energy monitoring protocols, they can begin generating reliable data that extends beyond individual projects. Over time, the availability of empirical evidence enables the private sector, NGOs, and national governments to make informed, independently grounded decisions about energy investment. Data-driven decision-making strengthens local accountability and informs humanitarian policymakers, ultimately delivering significant financial and environmental savings (Rosenberg-Jansen et al., 2022). If even modest improvements can be demonstrated through relatively simple data-collection mechanisms, the case for upfront investment in monitoring infrastructure becomes compelling. With funding constraints tighter than ever before, humanitarian organizations can no longer afford inefficient practices and must adopt more innovative approaches to delivering effective relief at a fraction of the cost.

CONCLUSION

With the foreign assistance landscape shifting rapidly, it is crucial that organizations adapt quickly to avoid catastrophic consequences of aid cutoffs. It is increasingly recognized that, given the scale of current and anticipated protracted crises, the humanitarian sector must plan energy interventions with development-oriented outcomes in mind (European Parliament, Directorate-General for External Policies, 2022). Zainab Usman argues in Foreign Affairs that a central problem with the aid industry is that its benefits have been spread too thinly across multiple domains rather than concentrated in productivity-enhancing sectors (Usman, 2025). She contends that development efforts should instead prioritize affordable financing for targeted investments in connective infrastructure, including electricity, telecommunications, and mass transit (Usman, 2025). Displacement settings present a critical entry point for improving humanitarian service delivery while advancing national and regional development goals through expanded energy access. Entering a new era of aid requires moving beyond temporary generator-dominated energy provision and toward semi-permanent infrastructure that can sustain long-term operations and extend electricity benefits to surrounding communities.

While displacement settings are inherently high-stress and operationally challenging for humanitarian workers, it is the communities living through prolonged and inadequately resourced crisis environments who bear the greatest costs. The Federal Government of Nigeria has a responsibility to pursue durable solutions to ongoing conflict and displacement, recognizing that peace and stability in the northeast will yield benefits for the country as a whole. Even if current conditions do not yet support large-scale public or private energy investment, there must nevertheless be a clear long-term objective for northeastern Nigeria. Humanitarian organizations therefore have both a responsibility and an opportunity to leverage energy systems as a foundation, supporting improved energy access today while laying the groundwork for longer-term regional development.

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Switching on Opportunity: Measuring Energy Access in South Asia through the Lens of Education, Gender, and Stratification Economics

Asreeta Ushasri, Kanishka Desai‡*

*Master of Environmental Management (MEM '26), Nicholas School of Environment, Duke University
‡Master of Public Policy (MPP '26), Sanford School of Public Policy, Duke University

INTRODUCTION

Electricity infrastructure has unique gendered outcomes on educational time use and decision-making power (Chandrasekaran et al., 2023). Existing studies find that electrification has a correlation with increased study time, a reduced burden of household labor, and higher school enrollment for girls (Winther et al., 2017). Rural electrification enhances the scope for children to learn after dusk, lowers reliance on costly or hazardous substitutes like kerosene lamps, and could enhance schooling outcomes (Kanagawa & Nakata, 2008; Bose & Shukla, 2020; Chatterjee et al., 2023). In South Asia, studies show that girls' education in rural areas is positively correlated with household facilities, where a number of basic services (cooking fuel, sanitation, water) correlate with electricity (Nair & Mishra, 2023).

Nevertheless, the literature also identifies limitations to these outcomes (Khandker et al., 2014; Banerjee et al., 2021; Acheampong et al., 2024). The potential to benefit from electricity varies with wider socioeconomic stability and quality of energy access. This literature highlights a central finding: electrification schemes alone cannot dispel such disadvantages without deeper structural transformation (Banerjee et al., 2021, Acheampong et al., 2024). While site-specific studies investigate energy access and gendered educational outcomes, comprehensive country-wide metrics on this topic are still emerging – even as the literature points to the relationship between gender and energy. Therefore, this paper aims to examine if and how researchers can capture the perspectives of stratification and feminist economics in national energy access surveys across South Asia.

THEORETICAL FRAMEWORKS

This paper draws on the disciplines of stratification and feminist economics. Energy justice scholarship epitomizes the principles of stratification economics; namely, to consider systemic exclusions and barriers in the persistence of wealth inequalities. Noted by Darity, generational wealth accumulation and household assets play a role in the stratification of communities long-term (Darity, 2022). Stratification economics seeks to explain intergroup disparity based on the unequal transfer of wealth across generations (Darity, 2022). Stratification economists note that individuals are concerned with their relative wealth and economic well-being compared to their own group identity and other groups, which relates to inter-group disparities (Darity, 2022; Clark et al., 2008).

Stratification plays a role in energy access. In some studies, the benefits of infrastructure development disproportionately accrue to already privileged households in terms of wealth, caste status, or residence (Khandker et al., 2014; Banerjee et al., 2021; Acheampong et al., 2024). Caste-based differentials enforce the result so that Scheduled Tribe and Scheduled Caste homes benefit less from electrification even when physically plugged in, as studies in India demonstrate (Khandker et al., 2014). In Nepal, evidence from the 1990s and early 2000s indicate that caste stratification perpetuates educational inequalities, coupled with gender-based stigmas (Stash & Hannum, 2001). In rural Pakistan, Jacoby and Mansuri found that primary school enrollment gaps persisted between girls and boys, as well as on the basis of caste stratification (Jacoby & Mansuri, 2011).

Feminist economists have highlighted the invisibility of women's economic contributions, such as care labor and informal income generation, in national statistics. Gross Domestic Product (GDP) is used as a comparable metric of countries' economic health (Messac, 2018; DeRock, 2019). Yet, this measurement fails to account for social reproduction and often veils women's economic contributions to society (Messac, 2018; Folbre, 2007). In response, feminist economists developed time-use surveys to accurately capture labor completed by individuals outside of the formal economy (Messac, 2018; Small, 2024). This paper draws on feminist economics by studying gaps in data collection practices and critically evaluating how aspects of energy access survey methods could render gender inequalities invisible.

WHAT COUNTS AS ENERGY ACCESS?

Policy-oriented reports place electrification as a cornerstone of human capital formation. The World Bank and IEA highlight that the expansion of electricity access drives Sustainable Development Goal 7 and promotes education, health, and gender equality (World Bank, 2021;

IEA et al., 2022). In addition to electricity connection, clean cooking energy remains a priority in developing economies. Clean cooking fuels can reduce indoor air pollution and promote gender equity, improving health outcomes while also addressing disproportionate household labor burdens (Nerini et al., 2026).

Access to a steady, safe supply is not the same as access to electricity (Sedai et al., 2021). Groh et al. note that the literature up until the mid-2010s predominately measured electricity access as a binary variable: whether or not a household has grid connection (Groh et al., 2016). Yet, empirical evidence demonstrates that the availability of energy drastically changes based on the reliability and quality of energy (Ayaburi et al., 2020; Dang & La, 2019; Groh et al., 2016; Chakravorty et al., 2014).

Measuring energy access as a binary construct erases structural inequalities such as load shedding, black-outs, high connection costs, and dimming or brown-outs. Load shedding occurs when electricity demand exceeds supply; select neighborhoods are cut off from grid electricity to prevent system overload (Timilsina & Steinbuks, 2021; Nduhuura et al., 2020). Blackouts and load shedding exist on a stratified spectrum due to varying spatial impact. These examples illustrate that comprehensive energy access depends on more than grid connection alone; reliability, capacity, affordability, legality and load types all play a role in revealing the true picture of energy access.

The mid-2010s witnessed a shift in data collection practices, as researchers started to measure energy connection beyond the binary construct. At this time, two notable surveys emerged in South Asia on energy access: the ACCESS survey in India, and the Multi-tier Framework (MTF) for Energy Access in Nepal and Bangladesh. The adoption of holistic metrics for energy access aligns with fundamental theories of stratification economics, with a recognition of the intersectional barriers that prevent full realization of energy security (Chester & McMaster, 2023).

Situated within the context of stratification economics and feminist economics, this paper considers how energy access data collection practices within these two surveys influence gender analysis in the field. The framework of describing energy access through tiered ranks, as opposed to a binary variable, relates to concerns around stratified outcomes. However, more indicators in national surveys can strongly address research questions around education, gender, and energy.

MULTI-TIER FRAMEWORK FOR ENERGY ACCESS (NEPAL)

The Multi-tier Framework (MTF), launched in 2015 by the Energy Sector Management Assistance Program, captures household-level metrics on capacity, reliability, affordability, duration, quality, legality, health and safety with respect to energy connection, shown in Table A

(Groh et al., 2016, World Bank, 2015). The MTF carries multiple matrices to measure energy access, reliability, use, and appliances. Given the priority and pervasiveness of dangerous cooking fuels globally, the MTF also includes comprehensive survey questions on cooking options in Table B (World Bank, 2015). The World Bank adopted the MTF as a more comprehensive survey approach to energy access starting in 2015, with six main tiers of electricity status.

Since its inception, 15 countries have adopted and deployed the MTF. A major strength of this survey is comparability across countries. While still approaching energy access through a multi-variable measurement tool, the survey provides a baseline guide for data collection across countries. In South Asia, Bangladesh and Nepal have participated in the MTF survey. The data collection methods for Nepal's MTF survey are publicly available; therefore, this paper focuses on findings from Nepal.

Of note, Nepal's MTF survey included a gender-specific interview guide, with questions on financial means, educational level, and mobility. The collection of individual education levels provides increased granularity on energy access impacts, along with socioeconomic indicators. This issue is explored deeply in the discussion section.

ACCESS SURVEY (INDIA)

In 2015, the Council on Energy, Environment, and Water (CEEW) sought to collect comprehensive data on clean cooking fuels and energy access in India (CEEW, 2018). Researchers developed a panel survey approach to interview households across six states: Madhya Pradesh, Uttar Pradesh, Bihar, West Bengal, Jharkhand, and Odisha (Jain et. al, 2015). This survey modified aspects of the World Bank's multi-tier approach, though this survey had four tiers of energy status instead of six. International organizations at this time visibly acknowledged the importance of measuring comprehensive energy access in reference to Sustainable Development Goal 7 (Narlanka & Balachandra, 2024; Chandrasekaran et al., 2023; Groh et al., 2016).

Under four different tiers, Jain et. al (2015) crafted survey questions to address capacity of electric connection, hours of availability, days of blackout, affordability, reliability and legality as portrayed in Table A (CEEW, 2018). Illicitly tapping electricity from the feeder occurs when constituents obtain connection without paying for electricity, which can lead to non-technical losses during the transmission process and destabilize power infrastructure (Depuru et al., 2011). After conducting this survey in 2015, researchers returned to the same households in 2018 to reassess electricity access levels (CEEW, 2018; Akter et al., 2023). The second survey similarly analyzed reliability and quality of electrification efforts in a multi-tier approach.

The ACCESS survey methodology included distinct questions about cooking fuels in both 2015 and 2018 given this persisting issue, shown in the Table B (CEEW, 2018). The following section compares the ACCESS India survey and MTF Nepal survey in detail, discussing strengths and limitations to each approach.

DISCUSSION: MTF-NEPAL AND ACCESS-INDIA SURVEYS

Applying a tiered categorization for energy access and clean fuels marks a distinct divergence from methodologies prior to 2010. While the ACCESS survey drew inspiration from the MTF, the largest difference is the unit level of analysis within survey questions.

Table A. Tiered Approach to Electricity Metrics

		ACCESS Survey (India)	MTF Survey
Electricity Metrics	**Capacity**	Measured by Watt, including appliances/uses (cooling, charging)	Measured by Watt OR appliances/uses (cooling, charging)
	Reliability	Number of blackout days per month	Number of disruptions per week (includes shorter duration disruptions)
	Duration	Number of hours of electricity in a 24-hour period	Number of hours of electricity during the day
	Quality	Number of high voltage days in a month	Binary variable: Whether or not high voltage harms appliances
	Affordability	Binary variable: affordable or unaffordable	Binary variable: Whether the cost of electricity per year is less than 5% of household income
	Legal Status	Binary variable: legal or illegal connection	Binary variable: Whether bill is paid to authorized utility
	Health and Safety	Not included	Binary variable: Absence of past accidents and future perceived risks

Comparison of the measurement techniques of both the ACCESS and MTF surveys. These are the main surveys which measure energy through a tiered system in South Asia.

Table B: Tiered Approach to Clean Cooking Metrics

		ACCESS Survey (India)	MTF (Nepal)
Clean Cooking Metrics	**Cookstove Efficiency**	Not included	Stovetop efficiency measured in tiers based on credible agency
	Convenience	Measured in terms of time-use and difficulty of use	Hours per week collecting fuel Minutes per meal for cooking
	Affordability	Binary variable: whether cooking operation is affordable or not affordable	Binary variable: whether or not fuel and operating costs is less than 5% of household income
	Quality	Binary variable: whether quality of cooking is adequate	Binary variable: whether the heat rate is stable for cooking
	Health and Safety	Type of fuel source used: either traditional fuels (firewood, dung), a mix of fuels, or only clean fuels (biogas, gas, electricity)	Safety and health measured as separate metrics
	Safety of Primary Cookstove	Not included	IWA safety tiers or past accidents (burns or fires)
	Indoor Air Quality	Not included (though fuel type is measured)	Particulate matter and carbon monoxide levels
	Availability of fuel	Cooking less because of availability or unsatisfied	Fuel is available at least 80% of the year, is available year-round, or has shortage issues

Comparison of the clean cooking tiered metrics across the ACCESS and MTF surveys. Though indoor air quality is not measured in the ACCESS survey, the type of cooking fuel is tracked. The type of fuel greatly influences air quality.

The MTF provides a basis for individual and household level data collection. In Nepal, surveyors collected data on individuals within a household with regards to mobility, financial means, educational level, and more. This is especially crucial when investigating gendered outcomes. Gender inequality persists within the household; therefore, individual data is crucial to understanding the intersectional impacts of reliable energy access. To this end, researchers have employed the MTF in a gendered context to consider women's empowerment and dynamics as related to energy access (Chandrasekaran et al., 2023).

The MTF demonstrates the possibility for comprehensive, detailed, and comparable quantitative data by providing a baseline classification method for tiers of energy quality. This survey bridges the gap between granularity and comparability. Very few countries on the global stage have completely adopted the MTF, which requires further incentivization. Despite this, the methodology offers comparability between countries and regions, while still capturing the nuances of reliable energy options.

While the MTF includes aspects of socioeconomic data collection, its limited questions on caste discrimination in Nepal's questionnaire runs counter to the literature's emphasis on the prevalence of caste stratification (World Bank, 2023; Stash & Hannum, 2001). Visibility in academic research on stratification is important to measure potential barriers. Therefore, developing a method to include context-specific stratification is crucial for bolstering future data collection. Researchers should consider incorporating questions on country-specific stratification and caste discrimination.

The ACCESS survey conducted in India includes indicators on caste stratification, a notable strength for data collection on generational inequalities. A limitation to the ACCESS interview guide is the focus on household-level analysis, especially given gender inequalities often occur within the home. Folbre (2020) and other feminist economists consider the household a place of financial bargaining with its own set of gendered labor inequalities and market power. In South Asia, girls' dropout rates are the highest during secondary school (ages 15–19) (Kumar et al., 2023). Within the household, individuals face different barriers to educational and economic opportunities. The ACCESS survey includes questions about the level of educational attainment for the household head, which addresses aspects of socioeconomic stratification, but the survey excludes educational metrics for each individual within the household.

The ACCESS survey has allowed researchers to analyze energy issues more deeply. Jain et al. found that only 68 percent of households had electric connection in 2015, even though 95 percent of villages were categorized as 'electrified' (Jain et al., 2015). By 2018, 80 percent of rural households surveyed relied on solar home systems or grid connection, a large increase from 2015 (CEEW, 2018). The literature demonstrates that electricity access in school buildings can increase school enrollment; yet, household lighting is crucial for study time. Therefore, village connection alone may not facilitate fully realized educational improvements. Furthermore, educational gains cannot be understood without collecting individual level data. The survey lacks metrics to fully understand gender inequalities within the household, illustrating a need for improvement in future data collection methods.

The implications of these findings are immense – electricity access changed dramatically in both countries during the survey timelines. To fully incorporate the theories of stratification and feminist economics, data surveys must collect information on an individual basis and include context-specific social stratification such as caste. Combined with household socioeconomic questions, this would create a viable dataset for an integrated stratification economics and feminist economics analysis in the future. Additional research should also consider how to create cost-effective survey techniques which still capture the detail, granularity, and inclusivity of multi-tier energy measurements.

CONCLUSION

Analyzing the ACCESS and the MTF surveys highlights that existing energy measurement approaches have strengths and limitations. Each provides considerable insight into household-level energy access and reliability, but national surveys have the power to provide even more insight on social stratification and gender-based indicators. These results reflect a broader epistemological issue: the persistence of invisibility in quantitative data. Researchers must incorporate gender-disaggregated and stratification-sensitive metrics – such as time-use patterns, intra-household decision-making, and school completion data – to understand the entire impact of energy system expansion. It is imperative that full-spectrum surveys are conducted on energy access, so that researchers can understand the holistic and intersectional factors that shape electrification impacts in communities. Ultimately, it will take more than turning on the lights to flip on opportunity. Incorporating the lens of stratification and feminist economics into data collection surveys can light up the social pathways toward justice and inclusion.

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Policy Improvements for Alleviating Elderly Energy Poverty in South Korea

Jiyeong Pyo

Master of Environmental Management (MEM ‘27), Nicholas School of Environment, Duke University

INTRODUCTION

Although Article 34 of the Constitution of the Republic of Korea states that every citizen has the right to live a humane life, the reality is that the minimum quality of life is not equally guaranteed across all classes (Constitution of the Republic of Korea, Article 34). Particularly vulnerable groups, including the elderly, people with disabilities, and non-regular workers, are expanding rapidly due to Korea’s unique population structure. With the lowest fertility rate (0.6) among OECD countries, Korea is aging at a fast pace. As of 2024, the elderly (aged 65 or older) comprise 19.2% of the total population, and this ratio is expected to exceed 20% by 2025, marking the entry into a super-aged society (Statistics Korea, 2024).

Despite various welfare policies, Korea has the highest elderly poverty rate among OECD countries. In 2020, the proportion of elderly individuals with incomes below 50% of the median income stood at 40.4%, well above the OECD average of 14.2% (OECD, 2023). The poverty rate among those aged 75 and older is even more severe, reaching 52%. This suggests limitations in the effectiveness of current welfare systems.

Current welfare policies for the elderly in Korea consist of basic pensions, retirement pensions, and senior employment programs, most of which focus on income maintenance and job creation. However, income support policies that provide a fixed amount of money often fail to improve quality of life, as they do not take into account the heterogeneous consumption behaviors of recipients. Bertrand, Mullainathan, and Shafir (2004) point out that income transfers may not necessarily lead to autonomous consumption depending on individual behavioral tendencies. Therefore, standardized income support programs should be designed to reflect the behavioral characteristics of recipients.

Furthermore, senior job policies are generally targeted at those younger than 75 who are still capable of working, which means that direct support for low-income elderly people who are no longer part of the labor force remains insufficient.

Among various forms of poverty affecting the elderly, energy poverty is the most threatening. According to Shin and Lee (2017), cited in Eom and Kim (2024), the elderly are the most vulnerable group in terms of thermoregulation due to the effects of aging. When adequate heating and cooling are not ensured during extreme temperatures, it can lead to deteriorating health and increased medical costs (Eom, S., & Kim, J., 2024). Thus, energy poverty is not merely a matter of insufficient income. It is a serious societal issue that directly affects the survival and welfare of older adults.

This study therefore focuses on energy poverty as a core aspect of elderly poverty. It analyzes the current definition of energy poverty and the existing support programs, then compares elderly and non-elderly households to examine the distinctive energy consumption patterns of elderly households. Based on this, the study identifies limitations in current energy welfare systems and proposes policy reforms aimed at addressing them more effectively.

THEORETICAL BACKGROUND AND PREVIOUS STUDIES

I. Energy-Poor Households

Previous discussions on energy-poor households have taken various approaches, but a unified definition has yet to be established. Internationally, energy poverty is typically defined based on income level or energy efficiency, and the definition differs across countries and institutions. For example, the European Union defines energy poverty as the inability of households to access adequate heating, cooling, electricity, or other essential energy services, emphasizing access to energy (European Commission, 2019). The United Kingdom defines it as a condition in which a household's residual income falls below the national poverty line after paying energy bills, thus combining income level and energy cost burden (BEIS, 2013). The United Nations Development Program (UNDP) focuses on access to electricity and clean cooking fuels as the core indicators of energy poverty, highlighting the issue of basic service accessibility. In contrast, according to Drehobl et al., (2020), the United States uses the concept of energy burden rather than energy poverty, considering a household as burdened when energy expenses exceed 6% or 10% of household income (U.S. Department of Energy, 2022).

Unlike these countries, Korea has not established a clear official definition of energy poverty, despite implementing policies to support vulnerable groups. Six major indica- tors have been used domestically to estimate the energy-poor population. Table A, re- constructed by the author based on indicators suggested by Lee et al. (2022), includes an analytical summary of their limitations and strengths. Yoon et al. (2019) further criticized the absence of official discussion on the definition and targeting criteria, even though the Korean government allocates approximately 400 billion KRW annually to energy support programs.

The definition and targeting of energy-poor households remain globally inconsistent. This lack of consensus may lead to targeting errors, thereby reducing both the effectiveness and efficiency of energy policies. Targeting errors are typically categorized into exclusion errors, where those who should receive benefits are left out, and inclusion errors, where benefits are misallocated to non-eligible individuals. According to Coady et al. (2004), exclusion errors undermine the effectiveness of policies, while inclusion errors waste public resources and reduce efficiency. Furthermore, Dietrich, Malerba, and Gassmann (2024) emphasize that such errors may be exacerbated by data biases or poorly designed criteria in the policy planning stage. They call for greater accuracy and fairness in policy implementation. Particularly in the absence of careful policy design, targeting errors can lead to the exclusion of those most in need or to the inefficient use of public resources.

Building on these discussions, this study focuses specifically on elderly households within the energy-poor population and aims to propose refined criteria to minimize targeting errors. By analyzing the energy consumption characteristics of elderly households and identifying the limitations of existing policies, we propose a more efficient and realistic set of tailored eligibility standards to inform future improvements in Korea's energy welfare policy.

II. Energy Voucher Program

Current energy welfare support in Korea is divided into two main categories: income-based subsidies for energy purchase and policies aimed at improving energy efficiency. Nam and Park (2020) argue that existing energy welfare policies fail to reflect differences in fuel costs, resulting in inadequate support for households that rely on high-cost fuels. This implies that current policies lack fairness in addressing the structural differences in energy cost burdens.

Although there are no energy welfare programs specifically targeted at elderly households, the Energy Voucher Program is the only scheme that explicitly includes the elderly in its eligibility criteria. According to the Korea Energy Agency (2023), this program provides vouchers to energy-vulnerable households, allowing them to purchase electricity, natural gas, district heating, kerosene, LPG, and coal to stay cool in the summer and warm in the winter.

Table A. Domestic Definitions and Limitations of Energy Poverty

Energy Poverty Indicator	Definition	Limitation
Minimum Energy Criterion	Households spending less than 70% of the average fuel cost per household size	Does not consider cost burden, only basic consumption
Fuel Expenditure Ratio	Households spending more than 10% of their gross income on fuel	May exclude households with low absolute consumption
Energy Voucher Criterion	Recipients of Basic Livelihood Security Program (30% of median income or medical aid) who meet household characteristic conditions	Policy-linked, but may exclude poor households not meeting demographic criteria
Benefit Receipt Criterion	Households below 30% of median income per Basic Livelihood Security Program	Reflects income and cost burden, but not actual consumption patterns
MIS (Minimum Income Standard)	Households whose residual income after housing and basic costs are less than required for energy	Reflects available income, but requires detailed data
MEPI (Multidimensional Energy Poverty Index)	Households in the lowest 3 income deciles, exceeding 10% energy cost ratio, and living in pre-insulation reform buildings	Multidimensional, but highly data-intensive

Eligibility is determined based on both income and household characteristics, and the voucher amount varies depending on the number of household members. Qualifying characteristics include being elderly, infants, people with disabilities, pregnant women, patients with severe or rare diseases, and members of single-parent or orphan households. The Ministry of Employment and Labor (2026) defined the elderly as individuals born before December 31, 1960, based on resident registration.

However, despite these detailed criteria, the support structure is uniformly applied to all recipients. As a result, the differences in energy consumption needs and patterns across recipient groups are not adequately addressed. The current policy design lacks flexibility, underscoring the need for a more tailored and differentiated support system to enhance policy effectiveness.

III. Previous Research

The Energy Voucher Program in Korea was first introduced in 2015 to support heating costs during the winter season and was later expanded in 2019 to include summer cooling support. Previous studies on the energy voucher system have primarily focused on evaluating the policy's effects before and after its introduction. For instance, Lee (2019) used the 2017 Korea Welfare Panel data, and Kim (2020) employed the 2019 Energy consumption survey for low-income households to assess the effectiveness of the voucher program. However, these studies rely on cross-sectional data from specific years, which limits their ability to capture long-term or time-series effects of the policy.

Notably, Park (2020) is the only study that focused specifically on low-income elderly households. Using the Korea Welfare Panel data and a difference-in-differences (DID) model, she found that energy expenditures increased up to the voucher limit by the third year after policy implementation. This suggests that low-income elderly households may have been under-consuming energy before the policy was introduced.

However, Park's study focused only on elderly voucher recipients, potentially over- looking non-recipient households. This raises the possibility of exclusion errors in policy targeting.

This study seeks to go beyond existing evaluations of policy effectiveness by examining why elderly households fail to consume adequate energy, focusing on both behavioral and structural factors. The goal is not merely to measure the policy's impact, but to identify the fundamental causes behind energy consumption decisions in elderly households, thereby providing insights for improved policy design.

CONCLUSION

I. Summary of Analysis

This study first analyzed the Fuel Expenditure Ratio to evaluate the financial burden of energy on Korean households with pooled regression model. The results indicate that elderly, low-income, and rural households are disproportionately affected, spending a significantly higher percent- age of their total budget on energy compared to younger, urban households. This disparity is largely driven by income constraints and the inelastic nature of energy as a basic necessity. However, housing type emerged as a critical mitigator: households living in apartments experienced a much lower financial burden, likely due to superior insulation and more efficient centralized heating systems.

Secondly, the study also examined Low-Efficiency Fuel Use to understand why certain groups remain dependent on outdated energy sources like kerosene or coal. While younger, urban populations have largely transitioned to high-efficiency fuels like city gas, elderly residents in regions such as Jeju and Gangwon remain stuck using inefficient energy. The analysis reveals that this is not merely a choice but a structural issue; the lack of modern infrastructure in rural areas, combined with the maintenance costs of older, detached homes, traps elderly residents in a cycle of fuel inefficiency. Ultimately, the data proves that age, geographic location, and housing type are the three primary factors determining whether a household enjoys modern energy security or remains in energy poverty.

II. Policy Recommendations

This study examined the impact of household and regional characteristics on fuel consumption efficiency, with the aim of proposing policy improvements to address energy poverty among elderly households. Based on the empirical findings, we propose that Korea's Energy Voucher Program be revised to more effectively alleviate energy poverty among elderly populations.

First, eligibility criteria should be updated to reflect both income and fuel cost burden simultaneously. Currently, eligibility is primarily determined by whether a household receives public assistance under the National Basic Livelihood Security Act. However, this criterion excludes many elderly households that fall through the cracks of the existing welfare system. In fact, according to Seong and Park (2023)., approximately 104,600 households (1.8% of all households) met the income threshold but were not receiving any social benefits. This exclusion is largely attributed to low awareness of the program and burdensome application procedures. To address this, the Energy Voucher Program should introduce a more inclusive criterion that considers both income and actual fuel cost burden, along with simplified application processes.

Second, even if a household's income level is above the eligibility threshold, it may still experience high fuel costs due to external conditions such as poor housing insulation. For example, Statistics Korea's 2022 Pension Report shows that the average monthly pension for Koreans aged 65 and older is only 650,000 KRW, which is far from sufficient to cover basic living expenses. Thus, a structural revision of the Energy Voucher Pro- gram is required to consider not only income levels but also environmental and housing conditions—especially residential energy efficiency—when determining eligibility.

Finally, this study emphasizes the need to reevaluate the current eligibility framework and policy approach in order to provide meaningful support for elderly households facing energy poverty. By incorporating fuel cost burden, housing characteristics, and broader accessibility criteria, the energy welfare system can be improved to deliver more inclusive and effective assistance to vulnerable populations.

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Struggles Post-Universal Energy Access: Viet Nam's Energy Transition

Ananya Aggarwal, Jessalyn Chuang, Malaika Martis

Master of Environmental Management (MEM '26), Nicholas School of Environment, Duke University

INTRODUCTION

Viet Nam's power sector stands at a pivotal moment. As one of Southeast Asia's fastest growing economies, the country faces the dual challenge of meeting rising electricity demand while pursuing its long-term decarbonization commitments. Despite achieving 100% electricity access and becoming a regional leader in renewable deployment, the power sector faces reliability risks from grid congestion and curtailment. Viet Nam has also put down ambitious clean energy targets in its 2023 Power Development Plan VIII (PDP8), which was revised in April 2025 to include 10-16.3GW of battery storage and 236GW of renewables by 2030 requiring over USD 135 billion in investment (Vu & Guarascio, 2023). Majority of the investment is expected to come from private sources but remains unfunded currently.

This case study examines Viet Nam's progress under the Just Energy Transition Partnership (JETP), using the emerging battery energy storage agenda to explore how domestic priorities and international financing intersect to shape a low-carbon future. Viet Nam's approach to mobilizing capital, reforming regulation, and balancing fossil and renewable resources provides one lens through which to view the next phase of global energy access: one where the challenge is no longer connection, but reliability, affordability, and resilience.

COUNTRY BACKGROUND AND ENERGY SECTOR OVERVIEW

With a population of 101 million and a GDP per capita of USD 4,700 in 2024 (up tenfold from under USD 500 in the early 2000s), Viet Nam is a fast-growing middle-income economy in Southeast Asia (World Bank, 2025). Its rise as a manufacturing powerhouse has driven electricity demand up at an average of 10-11% annually since the early 2000s (International Energy Agency, 2025).

Viet Nam achieved near-universal electricity access in 2019 (Macrotrends, n.d.) through a state-led rural electrification program, anchored by the state-owned utility Viet Nam Electricity

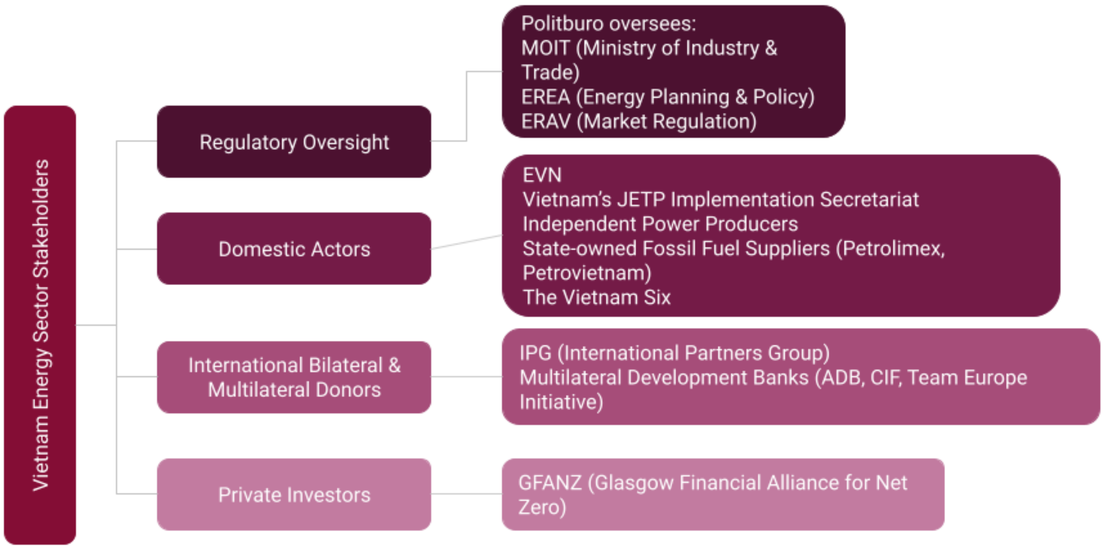
(EVN) and supported by concessional financing from institutions like the World Bank (Willcox & Cooper, 2018). As shown in Figure 1, this achievement needed large-scale transmission to enable long-distance bulk power transfers. However, this very infrastructure now constrains the energy transition. Many of Viet Nam's best wind and solar resources are concentrated in central and southern provinces, while major load growth is concentrated in the north (Ketelsen et al., 2023). Two 500 kV backbone transmission lines running through the country's narrow central corridor carry most north-south power flows, creating structural congestion and contributing to curtailment and reliability pressures (Vu Ba Hau, 2025).

Figure 1. Viet Nam's Electricity Transmission Network

Source: Energy Sector Management Assistance Program (n.d.)

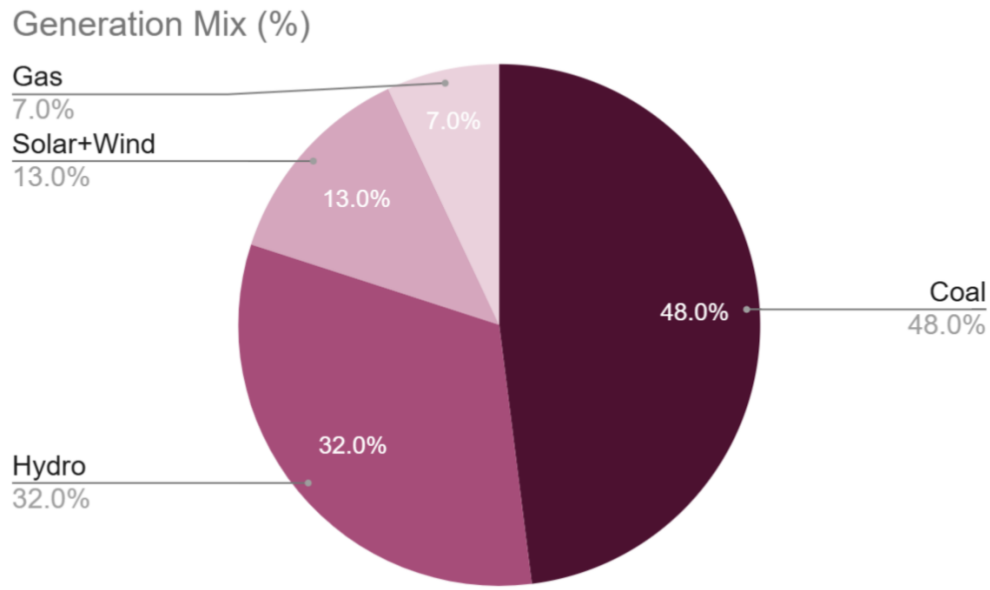
This state-led achievement was built on a highly centralized institutional model that remains largely intact. The Ministry of Industry and Trade (MoIT) oversees energy planning through the Power Development Plans (PDPs), while the state-owned utility, Viet Nam Electricity (EVN), controls transmission, distribution, and 37% of national generation capacity as of 2023 (Fitch Ratings, 2024). Although Independent Power Producers (IPPs), including foreign investors, make up over 60% of the generation capacity, all electricity must pass through EVN's transmission and distribution system – giving the state effective control over dispatch, grid access, and the terms on which private investment can operate.

Figure 2. Key Actors in Viet Nam's Energy Sector



In 2024, total electricity generation reached 308 TWh, with coal as the dominant source of baseload generation contributing ~48%. As of 2025, Viet Nam was the world's fifth largest coal importer, and leading in Southeast Asia. Hydropower provides about 32% but is vulnerable to seasonal droughts, while solar and wind together supply approximately 13%. Despite a considerable renewable share, per capita emissions have risen steadily from 1.60 tCO_2/capita in 2014 to 2.92 tCO_2/capita in 2022, underscoring the tension between economic growth and decarbonization.

Figure 3: Viet Nam's Power Generation Mix in 2024 (percentage shares)



Rapid demand growth and the need for energy security place significant pressure on the country to ensure a reliable supply that can meet the needs of its industrializing economy (Singh, 2025). Renewable expansion has slowed down since the solar boom in 2018-2021 (nearly 16GW added) due to lagging grid investment (Climate Chance, n.d.). Curtailment reached roughly 3.8% of solar generation in 2020 (Amperes et al., 2023) and further escalated to 10-15% by 2023 (Market Research Vietnam Consulting Firm, 2025). These bottlenecks highlight the urgency of grid investment and storage deployment.

Viet Nam's grid reliability has improved but remains below that of power systems in higher-income countries. In 2024, Viet Nam recorded a System Average Interruption Duration Index (SAIDI) of 199.83 minutes/customer and a System Average Interruption Frequency Index (SAIFI) of 1.95 times/customer, roughly a 25% improvement across both indicators since 2022 (Vietnam Electricity [EVN], 2023a). For context, Table A benchmarks these figures against international comparators. Reliability in many developing economies often exceeds 300 minutes of SAIDI and 3 or more interruptions per year, placing Viet Nam between typical OECD and developing-country averages, indicating meaningful progress, with further room to improve. On the physical grid, transmission losses have fallen from 12.23% in 2003 to 6.25% in 2022 (EVN, 2023b). But persistent grid congestion, localized outages during peak demand, and technical losses at lower-voltage levels point to structural challenges (EVN, 2023a). Without sustained investment in grid infrastructure and flexible resources, rising demand and growing penetration of variable renewables risk placing additional strain on system reliability in the years ahead.

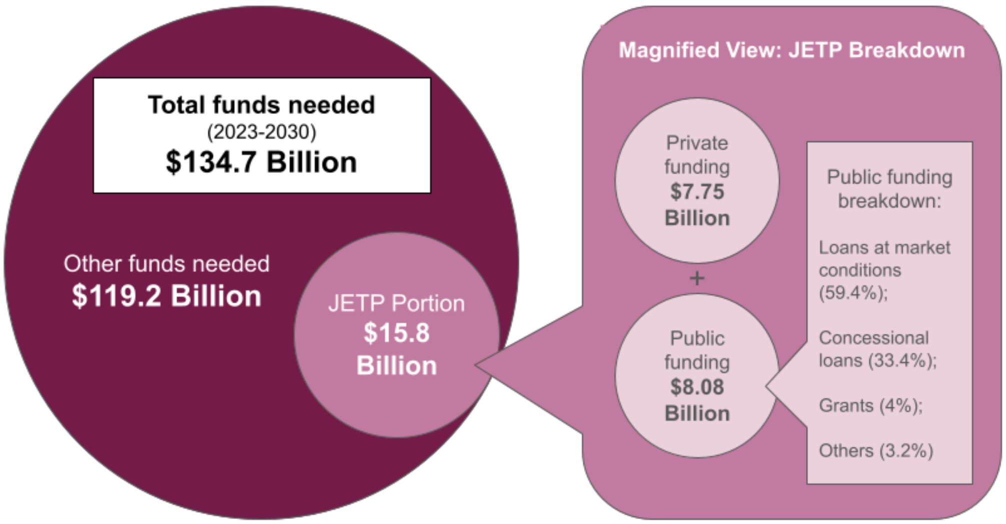
Table A. Global Comparators for SAIDI and SAIFI

Country/Region	SAIDI (min/customer-yr)	SAIFI (interruptions/customer-yr)
Singapore (Energy Market Authority, 2024)	0.26	0.006
Germany (StatRanker, 2025)	11.7	Not consistently reported publicly
Japan (StatRanker, 2025)	24.0	Not published
United Kingdom (StatRanker, 2025)	39.7 (reported as "customer minutes lost")	Not published
United States (U.S. Energy Information Administration, n.d.)	126	1.043
Developing economy average	>300	>3
Viet Nam	199.8	1.95

The government's feed-in-tariff (FiT) regime (2018-2023) successfully kickstarted renewable growth by offering above-market purchase prices over 20-year periods, which was funded through EVN (Nguyen & Hauber, 2025). However, the rapid build-out placed financial strain on EVN, compounded by retail tariffs of 7.5-9 cents/kWh that failed to keep pace with rising generation costs (Vietnam Electricity, 2025). EVN is now retroactively revising purchase prices for 173 solar and wind projects, putting over USD 13 billion in renewable investments at risk and alarming international investors by undermining confidence in the country's regulatory stability. Analysts warn the policy reversal could deter future clean-energy financing and raise capital costs for energy transition (Reuters, 2025).

At the same time, Viet Nam's energy sector is undergoing a significant policy shift. Under PDP8, the government has laid down a long-term pathway to gradually cap coal, expand renewables, and introduce new financing mechanisms for private investment, including the Direct Power Purchase Agreement Program (DPPA). DPPAs allow large electricity consumers to directly purchase renewable energy from generators, which is a divergence from Viet Nam's monopoly power market model (Nguyen & Apanada, 2024). The plan also calls for over USD 18 billion in transmission investment to have more than 10GW of battery storage online by 2030 (International Rivers & Vietnam Climate Defenders Coalition, 2024). Viet Nam's government estimates that USD 135 billion is needed for a just energy transition by 2030 (Market Research Vietnam by Eurogroup Consulting, 2025). As of 2025, 90% of this remains unfunded, and closing the gap will require foreign investment, public-private partnerships, and a regulatory environment credible enough to attract private capital at scale.

Figure 4. Funding Composition of the Viet Nam JETP



DONOR INVOLVEMENT AND HISTORICAL CONTEXT

Historically, Viet Nam's energy sector has relied heavily on bilateral official development assistance (ODA) from Japan, South Korea and China. Between 1993-2013, MoIT received ~USD 11 billion in ODA, with around 91% for the energy sector (Hoang, 2016). Between 2003-2018, more than 80% of Japanese and South Korean aid to Southeast Asia, and 60% of Chinese aid, was earmarked for fossil-fuel capacity (Bertheau & Lindner, 2021). This financed rapid economic growth but crowded out renewables and entrenched fossil-fuel dependency.

In recent years, however, donor behaviour has begun to shift. Japan and South Korea face mounting pressure to exit coal financing, and Viet Nam's transition to a middle-income status has reduced overall ODA flows, driving greater reliance on blended and market-based financing mechanisms. The centerpiece of current donor engagement is the Just Energy Transition Partnership (JETP), which was finalized in 2022-23 and mobilized USD 15.8 billion to support Viet Nam's shift away from fossil fuels. The partnership brings together the EU, the G7, and the International Partners Group (IPG), with financing channeled through multilateral development banks including the Asian Development Bank (ADB), World Bank, and European Investment Group (EIB). Technical assistance and regulatory reform efforts have also been led by USAID, multilateral institutions, and European partners (USAID, 2021). Unlike earlier project-by-project bilateral aid, JETP aims to support systemwide reforms, including coal phase-out, renewable integration, grid modernization, and enabling conditions for private investors.

JETP's Resource Mobilization Plan (RMP), presented in December 2023, outlines deployment of pledged funds across 400 potential projects. Of the USD 8.1 billion pledged to date, only a small share is grant-based, with most financing provided as loans, including USD 4.8 billion at market rates. While Viet Nam's gross debt has declined as GDP growth outpaces the budget deficit (Behind Asia, 2024), exposure to interest rate and exchange rate volatility remains a concern that could trap the country in a debt cycle. Uncertainty intensified following the US' withdrawal from JETP in March 2025. Civil society has also voiced concerns about aspects of the JETP, especially its continued support for coal-related infrastructure and limited transparency in project planning. For instance, Viet Nam currently operates 75 coal power plants and has plans to build at least 8 more, with CO_2 emissions expected to peak only in 2030. At the same time, the RMP contains no concrete timeline for coal phase-out and no specific commitments to retiring existing plants (Wischermann, 2024).

Against this backdrop, Viet Nam's efforts to develop its first grid-connected battery energy storage system, and associated technical assistance, provide a lens to evaluate how donor coordination, concessional finance, and capacity-building interact in practice.

THE ENABLE TECHNICAL ASSISTANCE PROGRAM

PDP8's April 2025 revisions significantly scaled up battery energy storage targets from 300MW in the original 2023 plan to 10,000-16,300MW by 2030. This reflects the shift in the country's priorities towards energy reliability and climate actions, improved financial and technical feasibility (driven by declining global battery costs and growing experience with grid-scale storage), and the availability of concessional finance under JETP. Within this context, Viet Nam has prioritized developing its first large-scale grid-connected BESS pilot.

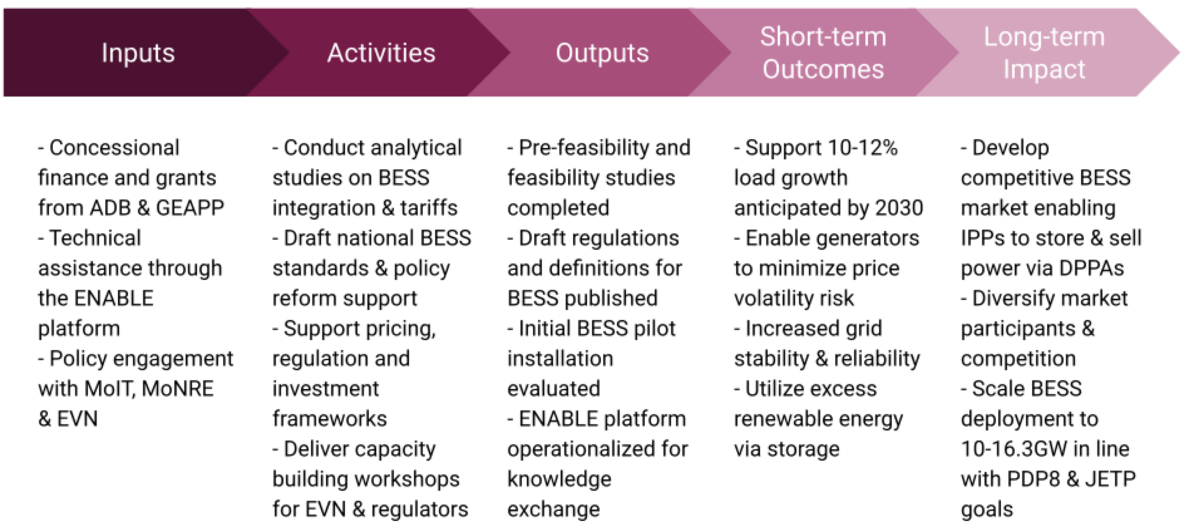
Supporting this effort is the Enhancing Access to Battery Energy Storage System (BESS) for Low-Carbon Economies (ENABLE) platform, launched jointly by the ADB and the Global Energy Alliance for People and Planet (GEAPP) in 2025. Funded through a USD 500,000 ADB grant and USD 250,000 grant from GEAPP, ENABLE provides regional technical assistance across Viet Nam, Cambodia, and Mongolia. Its expected outcomes include:

- Developing at least one policy recommendation to expand BESS application in at least one Developing Member Countries (DMC)
- Integrating at least one new BESS project into a selected DMC's PDP to guide private investment

- Establishing a sustained knowledge exchange and capacity-building platform, pooling expertise, data, and financing insights among governments, international experts, financiers, and developers.

By leveraging concessional and philanthropic capital to reduce early-stage uncertainty, ENABLE aims to crowd-in private investment as regulatory clarity improves in the region.

Figure 5. Authors' Theory of Change for pilot BESS program in Viet Nam



In parallel, Viet Nam's domestic institutions have begun advancing storage-related governance structures. The Electricity Authority of Viet Nam (EAV) under MoIT and Viet Nam Partnership Group (VEPG) launched the BESS Task Force on April 9, 2025, in Hanoi, supported by GEAPP. Operating under VEPG's Technical Working Group 3 (TWG3) on Grid Integration and Grid Infrastructure, the task force aims to conduct studies and co-develop knowledge resources covering best practices, technical capabilities, pricing mechanisms, ownership structures, financing approaches, and technical standards aligned with PDP8 objectives.

Regulatory changes have also gained momentum. Under amended PDP8 regulations, all new utility-scale solar plants must include battery storage of at least 10% of output capacity with two-hour operation capability, signaling a shift toward integrated solar-plus-storage design. Most notably, in October 2025, 15 national BESS standards were released by the Viet Nam National Standards and Quality Institute (VSQI), with support from the UN Office for Project Services (UNOPS) and the Southeast Asia Energy Transition Partnership (ETP). These were built on a combination of international standards and public consultation, covering technical parameters, planning and performance evaluation, environmental issues (reuse and disposal), and grid safety (TCVN, 2025). These mark significant progress for a country that previously lacked any legal structure for BESS. Significant challenges remain, however, particularly in establishing pricing mechanisms, defining BESS participation in ancillary services, and developing bankable revenue structures to attract private investment at scale.

ROLE OF AID AND IMPLICATIONS OF WITHDRAWAL

The ENABLE initiative reflects a broader shift in Viet Nam's engagement with foreign aid – from hardware financing to institutional, regulatory, and technical capacity-building. However, the sector's nascent stage means that grant-funded technical assistance and concessional financing remain foundational.

Reduced donor engagement would carry three compounding risks. Regulatory momentum depends heavily on grant-funded technical assistance; without it, policy coherence weakens. Battery storage projects carry high upfront capital costs and face uncertain revenue streams in emerging markets; concessional financing is essential to de-risk early deployment, and its absence would raise the cost of capital and stall the pipeline. Local banks and developers have historically covered most renewable investment, but they alone cannot close a USD 135 billion gap; and without concessional capital to bridge it, private financing will not be able to materialize at the required scale.

JETP's current financing remains dominated by multilateral public loans, while private financing has grown more uncertain following the exit of major banks from the Net-Zero Banking Alliance (NZBA) under GFANZ. Rising global interest rates and currency volatility further constrain affordable access to foreign-denominated loans. Premature withdrawal of donor support risks slowing regulatory development, raising the cost of capital for storage projects, and leaving the USD 135 billion financing gap unbridgeable at the pace PDP8 requires.

POLICY RECOMMENDATIONS

To advance Viet Nam's energy transition, partners should prioritize regulation and private investment enablement. Many renewable and storage projects are technically viable but stalled by regulatory uncertainty, weak revenue models, and limited institutional coordination. Technical assistance on market rules, grid codes, procurement standards, and ancillary service design, remains essential for translating project pipelines into bankable assets. Initiatives like ENABLE highlight how donor support can de-risk early-stage markets while incorporating international standards within domestic institutions. Technically sound regulation and transparency in expectations and financing are the most reliable guarantors of investor confidence.

Beyond technical assistance, Viet Nam should deepen the structural reforms already underway. DPPAs are a promising first step; further progress requires cost-reflective electricity tariffs, streamlined grid access and interconnection procedures, and a shift toward competitive renewable and storage auctions. Scaling blended-finance instruments, climate bonds, and risk-sharing tools (like partial credit guarantees and local-currency hedging facilities) can attract private investors wary of policy and market risk. Together, these measures can support a transition from donor-enabled pilots to commercially sustainable deployment, ensuring that Viet Nam's energy transition delivers not just lower emissions but also more reliable and affordable electricity.

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