



Article

Ethiopia's quest for energy security: challenges and policy options

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ABSTRACT

Energy security is at the heart of leveraging economic growth and social development, as well as environmental sustainability in third-world countries. An alarming rate of population growth, the society's energy demand, and the expansion of manufacturing and industrial production have further strained an already structurally vulnerable energy system in Ethiopia. Despite the country having made vital investments in renewable energy, particularly in hydropower, it still faces challenges related to climate variability, unequal access, institutional fragmentation, and regional geopolitics. This study examines Ethiopia as a multidimensional nation in terms of its energy security by assessing the social, environmental, institutional, and geopolitical constraints. The research employs a qualitative case study design, based on semi-structured interviews with key stakeholders and an in-depth review of policy documents, official government reports, and international datasets. Likewise, document review, as a tool, and thematic analysis, as a research method, are used to identify key patterns, risks, and policy gaps in energy system resilience. The results of the study showed that the high dependence on climate-dependent hydropower sources in Ethiopia presents the energy industry to supply volatility and financial difficulties, particularly in dry seasons. Poor rural electrification, reliance on traditional biomass, and inadequate transmission infrastructure are key drivers of end-of-life energy poverty and social imbalance. Institutional coordination issues and insufficient funds to expand these sources are among the barriers to diversifying renewable energy sources. Regularly, exporting electricity to foreign nations entails economic and diplomatic benefits, as well as political tensions and regulatory uncertainties. In the study, the researcher emphasizes the necessity of a comprehensive energy security system comprising climate resilience, social equity, institutional coherence, and proactive regional diplomacy. Policy guidelines focus on diversifying the energy mix, strengthening governance systems, decentralizing energy systems, and improving cross-border collaboration. The overall, inclusive approach can help Ethiopia increase the reliability, affordability, and sustainability of its energy system, as well as support national and regional development in the long term.

1. Introduction

Emerging Energy has been a major part of human development, supporting social and economic life throughout time. Since prehistoric times, people have depended on solar and somatic energy, and the development of industry marked a rise in energy use, which continues to influence sectors such as agriculture, industry, transport, education, health, and trade [1,2]. This means that only adequate and affordable energy can sustain development, effectively eradicate poverty, and serve as a measure of a society's well-being, as reflected in the strong association between the human development index and per capita energy consumption [3].

Energy security has become a central aspect of national and international policy. The definition of reliable energy, once defined in terms of eons of stable and affordable oil supply, has now been expanded to encompass reliability, sustainability, affordability, and environmental acceptability [4,5]. The four A's scheme, which includes availability, affordability, accessibility, and acceptability, further illustrates the multidimensional nature of energy security [6]. At the same time, there is also environmental security, which focuses on the safety of both human and natural systems from environmental hazards, whether induced anthropogenically or driven by climate change [7].

Fossil fuels currently provide approximately 80 percent of the world's energy, yet they pose a threat to both energy and environmental security because they are concentrated in local locations, are subject to price volatility, and emit greenhouse gases (GHGs). The solution is renewable energy, whose resources are all abundant, environmentally friendly, and increasingly cost-effective [8]. In Ethiopia, as in other developing economies, the prospects for a reliable energy supply continue to be challenged by heavy reliance on fossil fuel imports, poor energy sector efficiency, and unaffordable energy [4,9]. Ethiopia's renewable energy potential is substantial relative to the African average (Figure 1), with abundant hydropower, wind, solar, and geothermal resources [10].

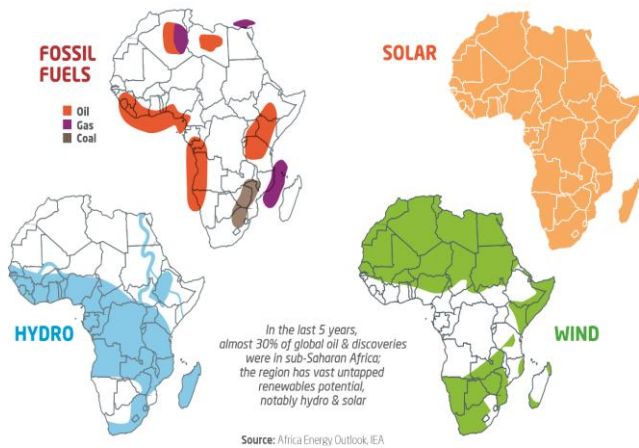


Figure 1. Ethiopia's electricity generation mix

The global energy environment is evolving rapidly due to resource depletion, climate change, and rising energy demand, especially in developing countries. Energy security policies must strike a balance between affordability and low-carbon energy options, as climate mitigation and conventional energy security objectives are not always aligned [11]. More coordination has been achieved through global governance mechanisms, such as the UNFCCC, OPEC, and IEA, but these bodies have limited capacity to resolve transnational energy and environmental issues [12]. Some lessons indicate that Ethiopia can secure energy through renewables, distributed generation, and efficiency measures, while balancing economic development with environmental protection [2,5]. Wind power generation trends (Figure 2) show fluctuating yet gradually increasing contributions to the national grid, highlighting both the potential of wind energy and the challenges posed by its variability [13].

1.1 Statement of the problem

Population growth, urbanization, and industrialization have increased global energy demand, placing growing pressure on nations' energy systems. Even though the world is working to achieve universal access to affordable and clean energy under Sustainable Development Goal 7, a significant gap persists between the developed and developing worlds, and Sub-Saharan Africa remains among the most energy-insecure regions. The energy security in Ethiopia remains a significant development challenge. Even after the country has invested heavily in renewable energy infrastructure,

primarily hydropower, over 85 percent of electricity production still relies on climate-sensitive water sources. This high dependence exposes the energy system to climate uncertainty and frequent droughts, heightening the risk of supply disruptions and financial losses.

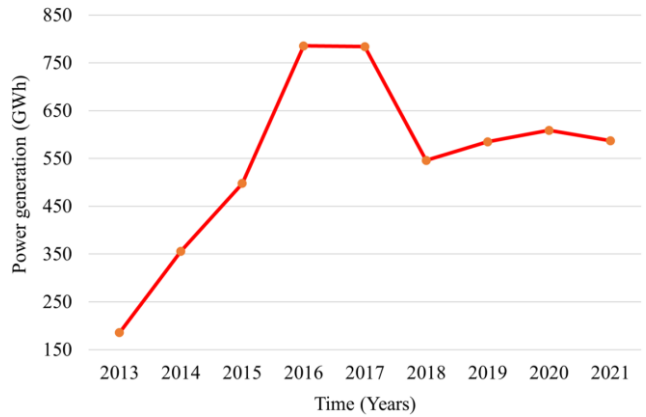


Figure 2. Ethiopia's wind power generation trend (Own elaboration using data from Ethiopian Electric Power)

At the household level, modern electricity services are still unavailable across Ethiopia, so traditional biomass continues to dominate energy consumption, especially in rural settings. Biomass utilization contributes to deforestation, health hazards, and environmental damage while intensifying energy poverty and inequality. Development in the energy sector is also complicated by institutional and financial factors. Disjointed governance, confusion of institutional mandates, lack of private-sector involvement, and ineffective regulatory mechanisms have hampered project implementation and reduced system efficiency. This has also been limited by insufficient funding for large-scale investment in renewable energy. Ethiopia is also playing an increasing role in regional and geopolitical events that affect its energy security, beyond its domestic issues. The country's goal of becoming a regional electricity exporter offers both economic and diplomatic potential but also presents weaknesses associated with political conflicts and transboundary waters [14].

Despite the available literature investigating the technical and economic factors of the Ethiopian energy sector, most studies examine these aspects separately. The relationship between social equity, climate vulnerability, institutional capacity, and regional geopolitics has been largely ignored. Consequently, responses to policies remain disjointed. Thus, the analysis should include social, environmental, geopolitical, and domestic institutional perspectives to better understand the continually evolving issues of energy security in Ethiopia. In the absence of this kind of integrated approach, there is the risk that the country will continue to face instability in its energy sector, limited development, and less resilience to climate and regional shocks. This research aims to fill this gap by examining the intricate causes of energy insecurity in Ethiopia and identifying policy alternatives to achieve sustainable, inclusive, and resilient energy growth.

1.2 Research objectives

The study basically focuses on analyzing the evolving issues of Ethiopia's energy security, with an emphasis on social and geopolitical factors. Additionally, it has specific goals:

- To come up with an energy security framework that incorporates human, environmental, and societal security.
- To determine the importance of energy security in the framework of the modern green energy transition in Ethiopia.
- To examine energy coordination in the region and its significance to the energy security of Ethiopia.
- To determine the domestic limitations and investigate the emerging dynamics of the energy security situation in Ethiopia.

2. Methodology

The research employed a qualitative approach to critically examine Ethiopia's energy security using historical, descriptive, and analytical methods. Its design was designed to encompass social, environmental, institutional, and geopolitical factors by utilizing both primary and secondary data sources. Qualitative case study: As Ethiopia is a case in point of a developing nation facing complex energy security challenges, the study employed a case study approach. In this manner, policy processes, institutional structures, and stakeholder perspectives can be analyzed in detail by considering the existing reality. The evolution of Ethiopia's energy sector is examined using historical and descriptive approaches, while analytical approaches assess emerging trends and weaknesses.

3. Data collection

Key informant interviews were used to collect primary data through purposive sampling between May and July 2025. This approach enabled the selection of participants with relevant professional experience and institutional involvement in the energy industry. A total of 18 key informants were interviewed, including officials from the Ministry of Water and Energy, the Ethiopian Electric Utility, the Environmental Protection Authority, the Ministry of Foreign Affairs, and academic institutions. The interviews focused on institutional coordination, policy implementation, climate-related risks, energy cooperation in the region, and investment limitations. All interviews lasted between 45 and 75 minutes, conducted either face-to-face or via secure online platforms. Participation was obtained with the interviewees' consent by taking notes and audio-recording the interviews as part of accepted qualitative study methods. As a method for this study, secondary data sources, including government reports, publications of international agencies, peer-reviewed journal articles, policy papers, statistical databases, and regional energy agreements, were employed. The most crucial sources were reports by the World Bank, the International Energy Agency, the United Nations agencies, and the Ministry of Water and Energy.

4. Data analysis

Interview-collected primary data underwent thematic analysis using transcribed data. The researcher systematically coded the transcripts to identify recurring patterns, themes, and relationships associated with energy

access, institutional performance, climate vulnerability, and regional dynamics. Triangulation of these qualitative results was conducted with secondary sources to enhance reliability and validity. The policy's approach to policy consistency, infrastructure development, financing mechanisms, and regulatory frameworks was analyzed using secondary data through document analysis and comparative review. Qualitative interpretations were supported by quantitative indicators, including the rate of electricity access, generation capacity, and the proportion of mixed energy.

4.1 Validity and reliability

Data triangulation was also used to enhance the credibility of the findings by cross-checking information from interviews, official statistics, and independent reports. Member checking was conducted with a few interviewees to assess the accuracy of the critical interpretations. Additionally, several sources were used to reduce the risk of bias and enhance analytical rigor.

4.2 Ethical considerations

This research was conducted in accordance with ethical standards and regulations. A high standard of ethics in qualitative research is essential. Any research needs to adhere to ethical principles. Gathering primary data through interviewing people requires trust-based relationships between the interviewer and respondents. Furthermore, it is critical to be aware of and abide by the scientific community's general agreements on what is acceptable and unacceptable in the conduct of scientific research. To this end, it is important for researchers to resist the temptation to manipulate their data collection, analysis, and interpretation procedures in ways that contradict the principles of science or the scientific method, or that advance their agenda. The respondents were free to participate in the interviews, and informed consent was gained. The participants also received assurances of confidentiality and anonymity, and no personal identifiers were included in the analysis.

4.3 Limitations of the study

The researcher has faced several constraints while conducting this research. The qualitative research limits the extrapolation of the results to settings outside Ethiopia. There was limited access to certain institutional documents and fine financial information. Moreover, regional political sensitivity to energy issues might have contributed to some respondents' openness. These restrictions were taken into account when interpreting the results.

5. Discussion

The research was assessed using a combination of historical, analytical, and descriptive methods, supported by interviews with policy officials, technical experts, and community stakeholders. From the broader perspective in terms of Energy Infrastructure, policy environment, historical context, geopolitical landscape, and environmental and social factors, it is obvious that Ethiopia's installed generation capacity reached around 5,300 MW by 2024, with more than 85% from hydropower [15]. Ethiopia's installed generation capacity reached around 5,300 MW by 2024. Historical growth in generation capacity over the past two decades (Figure 3) illustrates the continued dominance of hydropower in the country's energy mix, alongside the

gradual integration of other renewable sources such as wind and solar [16]. Transmission bottlenecks, high system losses, and delayed projects constrain electricity reliability. Ethiopia also has bold renewable energy plans through the National Electrification Program 2.0 (NEP), with the objective of universal access to electricity by 2030. Nonetheless, the weak institutional coordination and inadequate financing are the obstacles to implementation [17]. Notably, grid energy policy in this nation has been state-led and, through its great dependence on hydro-power mega-dams, i.e., Koka, Tekeze, and, more recently, on the GERD. It is a mixed legacy of both pros and cons; the former being restricted to renewable energy sources. In addition, the geopolitical conditions in the country for exporting electricity to Kenya, Sudan, Djibouti, and South Sudan reflect Ethiopia's desire to grow into a regional power hub. Nonetheless, political strains and Nile waters conflicts make this objective difficult to achieve [18]. Although considering the Environmental and Social Factors, deforestation, which significantly diminishes environmental sustainability (still 85 per cent of total energy consumption), makes population growth a viable choice to pursue, the population growth projection of 150 million by 2040 continues to place an unsustainable demand on electricity production. As this analysis demonstrates, the structural reliance on hydropower, institutional obstacles, environmental weaknesses, and regional politics indeed determine Ethiopia's energy security. Based on data from both primary and secondary sources, the researcher has critically analyzed the following key points in line with the research objectives.

5.1 Social dimension: energy access and human security

In Ethiopia, energy security takes the form of unequal access, mostly in the rural population (Table 1). Energy insecurity is also widely experienced in the country, especially in rural regions, where unequal access to power directly affects human development and social well-being.

The impact of low energy access on education, health, and livelihoods has been highlighted through interviews with local communities. In another example, people stated that children used candles to learn prior to the spread of electricity, and clinics failed to store vaccines in the fridge, a set of circumstances that negatively impacted learning and health (Community Interview, July 2025). This situation highlights the wider impacts of energy insecurity on human security: the lack of access to energy limits income-generating opportunities, contributes to poverty, and places an undue burden on women and children. The results of small-scale renewable solutions show that living conditions can be significantly improved, indicating that specific projects can counteract such setbacks. Nonetheless, these solutions are not yet all-inclusive, underscoring the urgency of implementing comprehensive policies, continued investment, and inclusive planning. Ensuring equitable access to energy is thus not only an issue of the technical realization of that infrastructure, but also a driver of both national and human security, as well as sustainable development, as social equity is directly related to higher energy security goals in general, as well as to environmental security.

Table 1. Electricity access by population segment (2023) [19]

Population Segment	Access Rate (%)	Primary Energy Source
Urban	95	Grid electricity
Rural	39	Biomass, kerosene
National Average	52	Hydro + Biomass

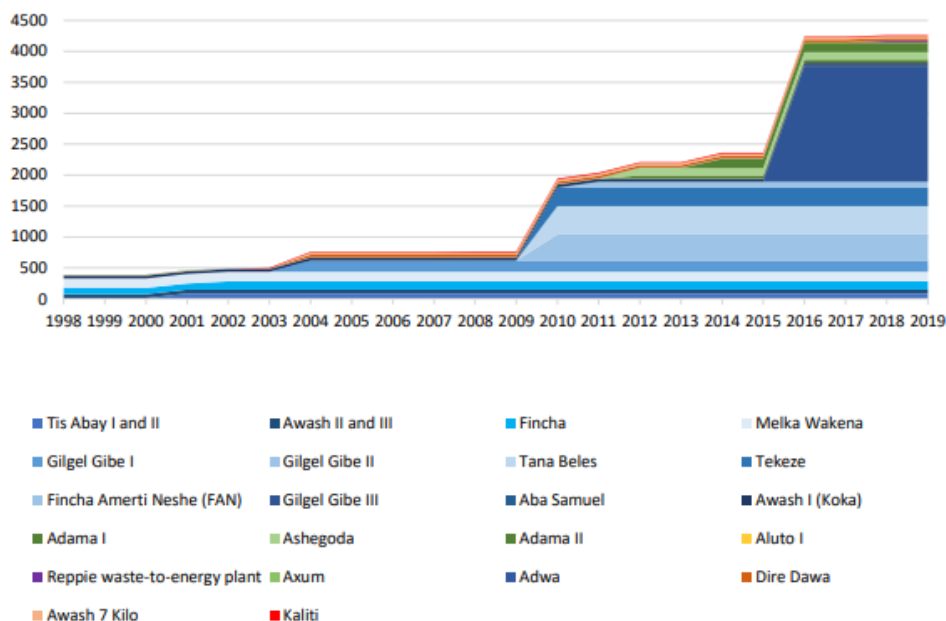


Figure 3. Installed electricity generation capacity: Ethiopia 1998–2019

Note: Blue = Hydropower. Green = Wind. Yellow = Geothermal. Purple = Biomass. Red = Diesel.

5.2 Environmental component: climate vulnerability

Ethiopia relies on hydropower for more than 85 percent of its electricity generation, making it quite dominant. Hydropower is both a renewable and a low-emission source of electricity, but is increasingly at risk from climate variability. Variations in rainfall patterns, prolonged droughts, and shifts in hydrological cycles significantly affect reservoir levels and river flows, thereby reducing electricity-generating capacity. Hydropower can fall by up to 20 percent in drought years, forcing the country to use costly, environmentally damaging diesel imports to meet demand.

As to the Environmental Protection Agency (EPA) expert, Hydropower dominates Ethiopia's generation (85%), but climate variability poses critical risks. The expert added, "Hydropower is highly climate sensitive. Drought years reduce output by up to 20%, forcing us to rely on costly diesel imports." (Interview, June 2025). Such dependence on weather-sensitive energy sources not only jeopardizes the stability and reliability of the power supply but also makes Ethiopia susceptible to both economic and environmental hazards. High diesel imports increase electricity prices, burden national expenditure, and cause greenhouse gas emissions. Additionally, the scarcer availability of electricity has the potential to diminish industrial productivity, increase reliance on basic services, and worsen social disparities, especially in rural settings, which are already vulnerable in terms of energy access. Hence, to address climate vulnerability and related issues in Ethiopia, the energy sector is fundamental and worth mentioning. Diversification of the energy mix through solar, wind, and geothermal energy, introduction of climate-resilient operations and management of hydropower, and improvement of regional energy cooperation could all help increase energy security while minimizing environmental and economic risks. The absence of these efforts places the country at great risk of climate shock, which would slow progress toward sustainable development goals and trigger the already prevalent negative effects of energy insecurity.

This underscores that climate variability is a significant problem in the Ethiopian power sector, since hydropower monopolizes the country's electricity supply, and even slight variations in rainfall or droughts over a considerable period would negatively impact energy production. This weakness has grave economic consequences, as the poor generation of hydropower forces the country to pay more for diesel imports and for their use, increasing power costs and burdening the national budget. This new move towards increased use of fossil fuels is detrimental to the country's climate mitigation agenda. At the social level, the lack of a reliable electricity supply affects basic services, such as health care, education, and industrial productivity, and, worse still, rural communities, which already face challenges in accessing energy. The overall consequence of the realities is that there exists an urgent necessity of the creation of strategic interventions by diversifying the energy mix in terms of solar-powered, wind and geothermal sources; incorporating more climate resilience in the operation of hydropower systems and more regional energy cooperation in an attempt to support energy security as an effort towards sustainable development and eliminating social economic and environmental risks of climate vulnerability.

5.3 Geopolitical dimension: regional coordination

The export of electricity to Kenya, Sudan, Djibouti, and South Sudan is a strategic opportunity for Ethiopia, underscoring the importance of global energy integration in the region. In this respect, Ethiopia is fervently endeavoring to provide electricity to its neighboring countries in the Horn as part of a regional integration process. The energy infrastructure improves regional dominance, the formation of new economic relations, and the affirmation of the country as a central participant in East African energy markets by integrating its infrastructure with the region's (Figure 4). These ties have the potential to foster regional stability by being mutually energy-dependent and collaborative in solving common problems, e.g. cross-border regulation of electricity and adapting to climate change. These advantages also go hand in hand with significant diplomatic and political risks.

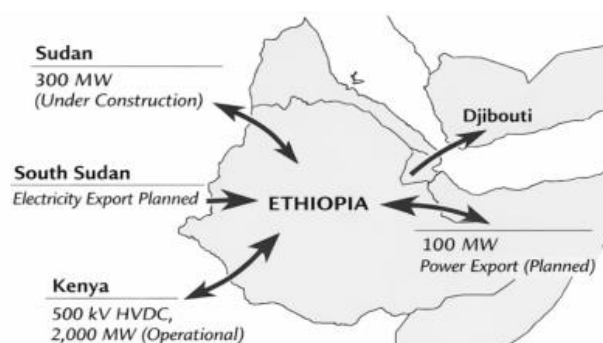


Figure 4. East Africa regional energy connections

In this regard, a diplomat from the Ethiopian Ministry of Foreign Affairs (MOFA) underscored that Regional interconnections increase Ethiopia's strategic leverage but also expose us to diplomatic risks, especially in Nile Basin negotiations." (Interview, July 2025, "Regional interconnections increase Ethiopia's strategic leverage but also expose us to diplomatic risks, especially in Nile Basin negotiations" (Interview, July 2025). The statement highlights the close connection between energy diplomacy and wider regional conflicts, particularly water resource management and geopolitical rivalries. As an example, the Grand Ethiopian Renaissance Dam negotiations are a delicate matter for the downstream countries, and agreements to export electricity to them can ignite tensions if undertaken without coordination. Moreover, being a passive participant in regional demand exposes Ethiopia to external shocks that can disrupt trade flows and lead to a subsequent decline in projected revenues due to political instability, changes in energy policies, or economic crises in partner states. Technical energy planning, proactive diplomacy, regional efforts to build trust, and sound legal frameworks can ensure regional energy integration, but caution is warranted to reduce political and economic risks. Such a duality demonstrates that Ethiopia's energy security strategy cannot be taken out of context in relation to its foreign policy considerations and regional coordination efforts (Table 2). Figure 5 demonstrates Ethiopia's net electricity exports from 2026 to 2040 under a reference scenario. The chart shows a steady increase from approximately 2 TWh in 2026 to nearly 10 TWh by 2040, driven by expanded hydropower and renewable energy generation.

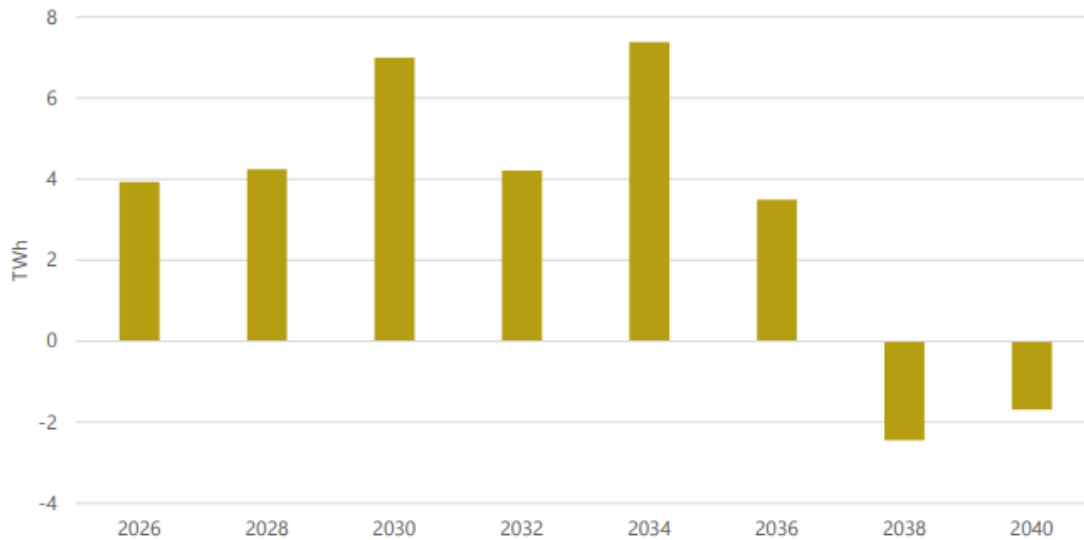


Figure 5. Net export in (TWh) in the reference scenario

This growth reinforces Ethiopia's strategic vision of becoming a regional energy hub, offering economic benefits while creating deeper regional interdependence. However, achieving this trajectory depends on favorable hydrological conditions, political stability, and timely infrastructure development [20].

Table 2. Key regional energy interconnections [21]

Partner Country	Transmission Project	Capacity (MW)	Status
Kenya	500 kV HVDC Line	2,000	Operational
Sudan	Interconnection	300	Under Construction
Djibouti	Power Export Line	100	Planned

5.4 Domestic constraints

National statistics indicate that Ethiopia has limited energy security due to internal factors, which make efforts to achieve a stable, reliable, and inclusive energy system complex. The first in-house challenge is institutional fragmentation and the overlapping roles among the Ministry of Water and Energy (MoWE), the Ethiopian Electric Utility (EEU), the Environmental Protection Agency (EPA), and the regional states. Such fragmentation indeed creates policy incoherence, delays in decision-making, and reduces the effectiveness of national energy initiatives.

According to the expert source from MoWE, "Policy overlaps and unclear mandates slow project implementation in the country. Many rural communities still lack electricity despite the government's priority of electrification in its national programs" (Interview, May 2025). Along with institutional challenges, financial shortages hinder the scaling of solar, wind, and geothermal capacity. Besides, limited access to long-term investment and dependence on external funding restrict the government's ability to plan and implement large-scale energy projects, leaving ambitious targets unmet. Infrastructure bottlenecks, which further exacerbate these constraints, especially in rural electrification, have also contributed to domestic constraints.

Above all, the Poor transmission networks, insufficient distribution capacity, and high costs of extending the grid to remote areas limit energy access and perpetuate inequalities. All of these in-house shortcomings not only slow the rate of energy growth but also reduce Ethiopia's susceptibility to external shocks, with climate variability and regional energy market volatility as the most common examples. These obstacles can only be overcome through combined policy frameworks, enhanced institutional coordination, new financing models, and infrastructure targeting to make energy security equitable and sustainable across all parts of the country (Table 3).

Table 3. Summary of domestic constraints [19]

Constraint Type	Description	Impact on Energy Security
Institutional	Fragmented mandates between MoWE, EEU, EPA	Delays, inefficiencies
Financial	Lack of private investment in renewables	Slower diversification
Infrastructure	Grid coverage limited in rural areas	Persistent energy poverty
Environmental	Droughts, climate variability	Unstable hydropower
Social	Unequal access to electricity	Energy injustice

6. Research findings

Based on the research problem, the analysis of the data collected revealed several findings below:

6.1 Constructing a system of energy security that accounts for the human, environmental and societal dimensions

The study's results demonstrate that Ethiopia's energy security cannot be achieved through technological means. The presence of human and societal aspects, including electricity supply in rural areas, the fair energy distribution, and social susceptibility, are parts and parcel of total energy stability. Environmental and human security are intertwined,

as climate-related effects on hydropower generation further contribute to environmental dependency, among other impacts on human security. Analysis reveals that in an isolated policy approach, the social equity and environmental resilience aspects of mitigation are likely to be overlooked, and the frequency of unequal access and vulnerability to the marginalized groups will be on the rise. The paper concludes that a comprehensive model that fuses these dimensions is necessary to enable risk prediction, resource maximization, and the facilitation of sustainable energy production.

6.2 Evaluation of the importance of energy security in the green energy transition in Ethiopia

Ethiopia has an energy sector in its early stages of development, heavily dependent on hydropower, with ongoing investments in solar, wind, and geothermal energy. The study shows that, although this green energy transition aligns with future climate goals and long-term sustainability, it will be subject to climate variability, funding shortages, and technological challenges. During droughts, hydropower generation may be reduced by up to 20 percent, making the system vulnerable to instability and forcing the country to import diesel to mitigate the impact. It is found that investment in diversified renewable sources and decentralized solutions, including solar mini grids, is important for securing a stable energy supply, reducing environmental risks, and making an equitable energy supply available to underserved communities.

6.3 Examining regional energy cooperation and its possible impact on Ethiopia's energy security

Regional energy cooperation comes out as a double-edged sword. Ethiopia should be the regional powerhouse in electricity exports, earning income by selling electricity to Kenya, Sudan, Djibouti, and South Sudan, benefiting economically and gaining strategic control over the region. The paper notes, though, that such benefits are measured by geopolitical risks. The politics of energy are closely linked to other regional tensions, notably in the Nile Basin, where water- and energy-sharing agreements are likely to influence export relations. The reliance on regional demand is also subject to fluctuations in politics and the economy within the partner states and thus demands legislative measures, development strategies, and active diplomacy to enable Ethiopia to rest in its energy trading business and competitive positioning in the region.

6.4 Determining the domestic restrictions and discussing the dynamics of the Ethiopian energy security landscape

At the local level, the research identifies several factors that impede energy security. Institutional fragmentation among the Ministry of Water and Energy (MoWE), the Ethiopian Electric Utility (EEU), the Environmental Protection Agency (EPA), and the regional authorities hinders decision-making and project implementation. The lack of financing and inadequate funding hinder the scaling up of renewable energy projects and impose infrastructure constraints that restrict access, thereby increasing social disparities and affecting rural electrification. With climate vulnerability coupled with geographical dependencies and constraints, we build a complex, dynamic energy security

environment. It is concluded that bottlenecks will be forced to come down through simultaneous policy actions by agencies with better institutional capacity, as well as selective investment in infrastructure that facilitates centralized and decentralized energy solutions.

7. Recommendations

Based on the research findings, the researcher forwarded the following recommendations:

7.1 Develop an integrated energy security framework

The Ethiopian Government should utilize a comprehensive approach that incorporates people, nature, and the public in its energy planning. The adoption of policies must focus on fair access to energy, societal well-being, and climate resilience, as well as technical and economic goals. These steps will involve incorporating climate resilience analysis into hydropower planning, ensuring that marginal and rural populations are included in energy programs, and circulating policies across ministries, regulatory bodies, and regional states to ensure consistency.

7.2 Switch and diversify their energy mix, as well as step into the green energy transition

The sensitivity of hydropower to climate change also underscores the need for diversification in the power supply. Ethiopia is well-advised to expand solar, wind, and geothermal energy sources and embrace decentralized energy generation systems, including mini-grids and off-grid solar systems, to boost electricity access in rural areas. Addressing the investment shortfall through public-private partnerships, related financing, concessional funding, and international climate funds could close the financing gap and accelerate renewable energy deployment. With diversification, system resilience will be achieved, reliance on expensive imported diesel will decrease, and the sustainability of development goals will be promoted.

7.3 Support energy cooperation and diplomacy in the region

The country needs to actively participate in regional energy regulation to become an energy hub in the region. Clear bilateral and multilateral engagement in initiatives such as the Nile Basin Initiative and joint infrastructure planning will be needed to lock in electricity exports and guard against these geopolitical risks. Integrating regulatory policies, exchanging technical know-how, and establishing mutual congeniality and trust between Ethiopia and other countries will increase economic and strategic returns and protect energy security by eliminating future disruptions to Ethiopia's energy supply chains.

7.4 Address institutional and infrastructure limitations in the domestic context

Fragmentation of the institutions, shortage of finance, and infrastructure bottlenecks are also key obstacles. The government needs to clarify institutional mandates, establish coordination mechanisms, minimize decision-making levels, and streamline intra-governmental coordination among the MoWE, the EEU, the EPA, and regional authorities. Specific investments in transmission and distribution networks, as well as in rural electrification, are particularly important. Capacity building of technical and managerial personnel, as

well as innovative financing controls, can enhance the efficiency of project implementation and the reliability of systems.

7.5 Reinforce climate adaptability and socioeconomic shocks

There is a need for adaptive management strategies to mitigate vulnerability to climate variability. They are the reservoir optimization, the water-and-energy-integrated system, and the early-warning system for hydropower variation. Another factor to anticipate is energy policy shifts, including shifts in demographics, urbanization, and industrialization, with the expectation of scalable, adaptable solutions that do not compromise reliability, equity, or sustainability.

8. Conclusion

This paper has explored the evolving issues of energy security in Ethiopia by taking a holistic approach that considers social, environmental, institutional, and geopolitical factors. The results indicate that Ethiopia's existing energy system is highly vulnerable, as it still relies heavily on climate-dependent hydropower and is marked by unequal access to electricity and organizational flaws in governance and funding systems. Climate variability has also posed environmental risks to the consistency of electricity supply, especially during drought seasons, when increased reliance on expensive, environmentally harmful fossil fuel imports becomes necessary. Simultaneously, poor rural electrification and reliance on traditional biomass exacerbate energy poverty and undermine social development outcomes. These issues explain why energy security, human welfare, and environmental sustainability are closely interrelated. Other factors that limit the successful execution of energy policies and infrastructure projects include institutional fragmentation and poorly designed investment schemes. Cases of poor coordination among major agencies and low private-sector participation slow the pace of diversifying and modernizing the energy system. Moreover, Ethiopia is rapidly becoming an electricity exporter in the region, with strategic prospects and geopolitical dilemmas; thus, there is a need to strike a delicate balance between energy planning and foreign policy objectives. All in all, the paper brings out the point that Ethiopia's energy security problem cannot be addressed through technical solutions alone. It requires a very comprehensive, holistic policy strategy that focuses on climate resilience, social equity, institutional coherence, and regional cooperation. The process of reaffirming decentralized renewable energy systems, improving the quality of regulatory frameworks, and fostering cross-border cooperation will be imperative for developing a resilient and inclusive energy sector. With an integrated and proactive energy security policy, Ethiopia will be able to reduce both climate and political shocks, increase sustainable economic development, and promote regional integration. This strategy will be critical in providing a quality, affordable, and eco-friendly energy supply to support long-term national development aspirations.

Ethical issue

The author is aware of and complies with best practices in publication ethics, specifically concerning authorship (avoidance of guest authorship), dual submission, manipulation of figures, competing interests, and compliance with policies on research ethics. The author adheres to publication requirements that the submitted work is original and has not been published elsewhere in any language.

Data availability statement

The manuscript contains all the data. However, more data will be available upon request from the corresponding author.

Conflict of interest

The author declares no potential conflict of interest.

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