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Ethiopian Energy Outlook 2025

Prepared by:

Ministry of Water and Energy (MoWE)
Ethiopian Electric Power (EEP)
Ethiopian Electric Utility (EEU)
Petroleum & Energy Authority (PEA)

Abbreviations

ASCENT	Accelerating Sustainable & Clean Energy Access Transformation
CKD	Completely knocked-down
CO_2	Carbon dioxide
DC	Direct current
DSO	Distribution System Operator
EAPP	East Africa Power Pool
EEP	Ethiopian Electric Power
EEU	Ethiopian Electric Utility
ETB	Ethiopian Birr
EU	European Union
EV	Electric vehicle
GERD	Grand Ethiopian Renaissance Dam
GHG	Greenhouse gases
GW	Gigawatt
HV	High voltage
HVDC	High-voltage direct current
ICE	Internal combustion engine
IPP	Independent Power Producer
LAMC	Liability and Asset Management Corporation
LCOE	Levelized cost of Energy
LNG	Liquefied natural gas
MW	Megawatt
NEP	National Electrification Program
PEA	Petroleum & Energy Authority
PJ	Petajoule
PPA	Power Purchase Agreement
PV	Photovoltaic
RE	Renewable energy
SAPP	Southern African Power Pool
TOU	Time-of-Use
TSO	Transmission System Operator
USD	United States Dollar
VAT	Value added tax

Foreword

Ministry of Water and Energy (MoWE) and Ethiopian Electric Power (EEP) published the first Ethiopian Energy Outlook in 2022. The outlook is meant as a review of the current energy policy. The purpose is not to give detailed recommendations – but more to give a solid foundation for a discussion of key issues within energy policy. In the current outlook, also Ethiopian Electric Utility (EEU) and Petroleum & Energy Authority (PEA) are participating.

The starting point is to develop a critical and facts-based analyses – with a focus on economic efficiency. It is fully acknowledged that many other relevant perspectives exist, like dilemmas between economic efficiency and regional equality or the priority of end-users with limited purchasing power.

Danish Energy Agency and the Royal Danish Embassy in Addis Ababa has supported the update of the Outlook.

The Outlook has been developed in close cooperation with all partners with strong commitment, openness and good discussions. It is the ambition that the Outlook in the same way can contribute to the development of the Ethiopian energy sector.

H.E Dr. Ing. Sultan Welle Ahmed
State Minister, Energy Development
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1. Executive Summary

Ethiopia's energy policy plays a crucial role in shaping the country's economy and the well-being of its population. This second Ethiopian Energy Outlook aims to support policy development through fact-based and critical analysis. Since the release of the first Ethiopian Energy Outlook in 2022, key reforms and policy shifts have significantly impacted the energy sector and thereby motivating the development of this Outlook.

1.1 Challenges and opportunities in the energy sector

The energy sector in Ethiopia faces several challenges:

Severe hard currency shortages have made new investments difficult, with approximately 25% of the country's installed power generation capacity remaining inactive due to difficulties in obtaining spare parts for maintenance. The exchange rate reform is expected to improve the situation.

Limited private sector involvement has hindered progress, as the business environment remains underdeveloped, causing delays in Independent Power Producer (IPP) auctions for solar and wind projects. Two auctions for private owned solar power generation have been announced as of February 2025.

The reliability of electricity supply is a major issue, with daily power cuts disrupting businesses and households, increasing reliance on expensive, imported diesel generators. EEU statistics for large users are: 39 interruptions per month, with an overall duration of 21 hours (3%)[1].

High inflation and a low electricity tariff have weakened the financial stability of the power sector, limiting resources for grid expansion and maintenance (EEP and EEU).

Internal national security concerns continue to affect energy infrastructure projects. Conflicts in Sudan, South Sudan, Yemen, and Somalia are delaying Ethiopia's ability to strengthen energy cooperation with neighbouring countries and export electricity.

On the other hand, there are also several opportunities:

Power generation to the national grid is already *100% renewable*, with hydropower as the dominant source.

The Grand Ethiopian Renaissance Dam (GERD) is beginning to yield significant returns, currently generating up to 2,350 MW with 6 of a planned 13 turbine have been commissioned to date.

The country is earning foreign exchange through electricity exports to Sudan, Djibouti, Kenya and Tanzania. Recently, the export to Sudan and Djibouti has decreased, while export to Kenya and Tanzania has increased.

The growing electricity demand from data centres (crypto mining) is expected to contribute more than 8 TWh in 2025 – corresponding to 30% of total demand. Since the demand/supply balance is tight, It remains an open question whether the power could be better used for export, general electrification or other productive uses, like pumping of water in the water and agriculture sector, where diesel generators are used to a wide extent. Increasing tariffs are likely to reduce the incentive to invest in crypto mining in Ethiopia.

Rapid adoption of electric vehicles (EVs) is reducing reliance on costly fuel imports while leveraging Ethiopia's renewable energy resources.

Ethiopia has vast, largely untapped solar and wind resources, along with hydropower projects with strong economic potential.

The country also possesses significant natural gas reserves that, if properly developed, could provide an additional energy source for export, industrial applications and/or power generation during dry years.

1.2 Recent policy developments

Economic reform: shift to a market-based exchange rate

In July 2024, Ethiopia transitioned to a market-based exchange rate system, allowing the Birr's value to be determined by market forces. This reform aims to address foreign exchange shortages, reduce the gap between official and black-market rates, and enhance economic competitiveness. After the reform, the exchange rate went from 54 ETB/USD to 125 ETB/USD. While the immediate effect has been a sharp devaluation of the Birr - leading to higher import costs and inflationary pressures - the long-term goal is to boost investor confidence, attract foreign direct investment, and improve economic stability.

Electricity tariff adjustments (2024-2028)

The Ethiopian Electric Utility (EEU) and Ethiopian Electricity Power (EEP) have consulted the government and Petroleum & Energy Authority (PEA) and announced a phased increase in electricity tariffs over the next four years, with nominal tariffs expected to rise by 400% by 2028. This adjustment is necessary to recover costs and improve EEP's financial stability and provide EEU with the capacity to maintain and expand the distribution grid.

[1] If it is assumed that 10% of the missing electricity from the grid is delivered by back-up diesel generators this will require 16 mill litres of diesel.

To ease financial pressure on EEP, a significant portion of its debt has been transferred to the Liability and Asset Management Corporation (LAMC), strengthening its financial position.

Achieving cost-reflective tariffs is essential for the financial stability of the power sector. A significant step has been taken with the 2024-2028 Tariff Adjustment Plan. High inflation may require additional corrections. For the acceptance of the high tariff increase it is important that improvements in security of supply continue, and that electrification will accelerate.

The rising costs may pose challenges for poor households. A seven-step progressive tariff for households protects the users with a limited demand.

With higher prices, consumers may prioritize energy efficiency and explore rooftop solar PV. EEU must be prepared to integrate these developments into the grid effectively.

High taxation on internal combustion engine vehicles

To promote the adoption of electric vehicles (EVs), the Government of Ethiopia has imposed high taxes on internal combustion engine (ICE) vehicles. More than half of all new personal cars are now EV. This is a significant result – also in a global perspective.

It is estimated that there are around 15,000 EVs (person cars) in Ethiopia, which is around 5% of all personal cars and accounts for 0.2% of the total electricity demand.

The number of EVs is still far from the goal of 148,000 in 2030. With an assumed rate of new car (all types) of 20,000 per year, it may be difficult to reach the goal. Costly imports may continue to restrict the number of new cars, despite the current car ownership ratio (cars per capita) being very low.

The growing adoption of EVs is a positive shift toward energy security and sustainability. All charging currently occurs at home, minimizing infrastructure costs. However, challenges remain in developing a widespread public charging network and ensuring the availability of authorized importers and maintenance providers. As EV numbers increase, the additional demand on the electricity grid will generate extra revenue but will also require EEU to upgrade infrastructure to improve reliability.

Slow electrification progress

Despite ambitious targets, the electrification progress has been slower than expected. Nearly 50% of the population still lacks access to reliable electricity, and only 22% have legal (metered) grid connections. The slow expansion of electricity access hinders economic development and reduces the potential benefits of other energy sector reforms. Addressing this issue requires increased infrastructure investment and innovative solutions to extend energy access to underserved areas. The respective tariff and exchange rate reforms are expected to alleviate the lack of materials for electrification – one of the main barriers to its progress.

Expanding electricity access is fundamental to economic development. While the current distribution grid covers only 25% of Ethiopia's land area, 68% of the population resides less than 5 km from the grid. This highlights the potential to triple the number of household connections within the footprint of the existing grid. Implementing cost-reflective tariffs will provide EEU with resources for new connections, making widespread electrification more feasible.

Mini grids are relatively expensive and are expected to have a new role in the update of the electrification plan. Mini grids should only be located in remote areas far from the national grid (e.g. more than 25 km from the current grid). In NEP 2.0, mini grids were also expected to serve as a bridging solution. However, investing in mini grids (solar based with batteries) and connecting them to the national grid after a few years is a very expensive approach.

Encouraging private investment in power generation

Currently, all operational power plants in Ethiopia are under the state-owned EEP. Future investments in hydro, wind, solar, and geothermal projects is planned to have private ownership, with EEP acting as the primary electricity purchaser.

Solar PV IPP auctions were announced in February 2025, with a total capacity of 225 MW in Gad and Weransso. The deadline for prequalification is April 2025.

Establishing a Transmission System Operator (TSO) will be crucial for ensuring a fair and transparent power market, mitigating concerns about competition between private and state-owned generation facilities.

Organisational changes may also be relevant for electrification and for mini grids. This could lead to an EEU focused on central distribution system operator (DSO) tasks.

Early deployment of hydropower projects should be prioritised

In the medium term, multiple hydro candidates are the most cost-effective power plant investment options and drive net exports. Revenues generated from electricity exports could be used to support continued electrification.

Delayed hydropower investment will likely exacerbate unrealised domestic demand and export potential, and impact Ethiopia's position in regional power trade.

Updated feasibility studies are a prerequisite for hydro plant investment, to ensure the long-term sustainability and profitability of selected investments.

While Ethiopia is dominated by hydropower, this is not the case for the region. Cross-border trade can be an important part of balancing the varying generation from hydro power.

The Ethiopia-Kenya interconnector facilitates regional electricity trade

Kenya is consistently Ethiopia's leading power trading partner in power sector development scenarios. To enable optimal trade, ensuring the Ethiopia-Kenya interconnector can operate at its full capacity (1,200 MW) by 2030 should be a priority. The grids in both Ethiopia and Kenya should be strengthened to accommodate the increased power flows.

Electricity trade should consider marginal costs in cost-reflective, dynamic tariffs.

Transitioning to trade of electricity based on marginal pricing aligns with the strategic objectives of the Eastern Africa Power Pool (EAPP). This would ensure fair pricing, promote efficient resource utilisation, maximize export revenues, and attract investments to position Ethiopia as a key player in the regional electricity trade.

Regional CO_2 emissions are significantly impacted by Ethiopian development

Ethiopia supplies clean electricity, reducing regional emission through exports. Trade restrictions raise regional emissions, underscoring Ethiopia's importance in lowering regional CO_2 emissions. Exports from Ethiopia can for instance reduce the use of diesel-based generation in the region, e.g. in Somalia, Eritrea, and South Sudan. However, security issues and the absence of national power grids in some countries may pose significant challenges and delay progress.

Improving grid reliability

Frequent power outages remain a major obstacle for businesses and households. On average, businesses experience 39 interruptions per month, with an overall duration of 21 hours (3%). Households face even more frequent interruptions, disrupting daily life and economic activity.

Investing in grid modernisation, increasing capacity, and deploying real-time monitoring systems will reduce the frequency and duration of outages. Addressing the backlog of maintenance for critical infrastructure such as switching stations and transformers will be essential for improving supply reliability. Installation of new underground cables in relation to the wide-spread corridor project in many towns is expected to strengthen the distribution grid.

Cancellation of natural gas project

The Government of Ethiopia has cancelled the planned natural gas extraction in the Ogaden region, and a pipeline project to Djibouti for export as LNG. Challenges in securing project financing and slow project implementation contributed to this decision. This cancellation limits Ethiopia's ability to generate revenue from natural gas exports and diversify its energy sources. Use of domestic natural gas would increase CO_2 emission, but could be a relevant option to balance generation in dry years and reduce the need for fertiliser imports. Ethiopia is currently extracting coal for industrial use.

2. Energy Landscape

Ethiopia's energy landscape is at a critical juncture, presenting both significant opportunities and notable challenges. The Government of Ethiopia has set ambitious policy goals, leveraging the country's substantial renewable energy potential to drive transformative changes in the sector. The focus on expanding electricity access, diversifying energy sources, and building a resilient and sustainable energy system is central to the long-term development strategy.

Effective policymaking is crucial in unlocking Ethiopia's energy potential by attracting investment and fostering private sector participation. However, the effectiveness of these policies will depend on consistent implementation and the ability to navigate complex regulatory and market dynamics. Inflation remains a key challenge, increasing the cost of energy infrastructure projects due to supply chain disruptions and currency depreciation. Addressing inflation through sound macroeconomic policies is vital to ensuring a stable financial environment that encourages energy investment.

The National Electrification Plan 2.0 aims to achieve universal electricity access, a goal that could significantly impact socio-economic development. Despite some progress in grid expansion, logistical and financial barriers continue to hinder electrification efforts.

Ethiopia also aspires to become a regional power hub, requiring investment in cross-border transmission infrastructure and the effective management of regional energy markets. While this vision presents economic growth opportunities, it also brings challenges related to regional cooperation, infrastructure development, and energy diplomacy.

The adoption of electric vehicles (EVs) is another key aspect of Ethiopia's energy transition. This shift is supported by tax incentives. Creating a nationwide infrastructure remains a barrier to widespread EV adoption. Developing local, certified expertise in EV maintenance and ensuring an adequate supply chain for spare parts will be critical to the sector's success.

Biomass continues to dominate the energy mix, particularly in rural areas, where traditional biomass sources such as wood, charcoal, and dung account for nearly 90% of total primary energy use. While biomass is a renewable energy source, its inefficient use contributes to deforestation, soil degradation, and indoor air pollution. Promoting modern biomass technologies (including biogas), improving energy efficiency in biomass consumption and e-cooking are essential to mitigating these environmental and health impacts.

Natural gas represents another potential energy source, with proven reserves in the Ogaden Basin. However, the sector remains undeveloped. A major project to extract gas from Ogaden and transport it to Djibouti for conversion to LNG was cancelled in 2022. The future role of natural gas in Ethiopia's energy mix will depend on the feasibility of new extraction and distribution projects, alongside economic and geopolitical considerations. Natural gas could potentially be used to compensate for the missing generation from hydro in dry years.

The energy sector is poised for significant change, driven by policy initiatives and the significant renewable energy potential. Navigating this evolving landscape requires addressing both opportunities and challenges with strategic planning and investment. This chapter will provide a deep dive into four urgent areas shaping the future of the energy sector: Electrification; Electric vehicles; Biomass; Natural gas.

2.1 Energy balance

Energy demand

In 2022, Ethiopia's total final energy consumption reached 1,855 PJ. Biomass (primary and derived) remained the dominant energy source, constituting 86% of total consumption, primarily for cooking. Oil products accounted for 11%, while coal contributed 1%. Electricity consumption made up only 2% of total final energy use.

Since 2011, Ethiopia's final energy consumption has increased by 40%. Electricity consumption more than tripled after 2011, but data about biomass use is very uncertain. Four pilot surveys have been conducted to improve data. The survey indicates that the average wood consumption per household in the selected regions is close to the average in the national statistics, while the charcoal use seems to be higher than the national statistics.

Final energy consumption 2022 (PJ)	Biomass	Oil products	Coal	LPG	Electricity	Total
Industry and construction	-	15	24	-	10	49
Transport	0	181	-	-	0	181
Households	1,581	4	-	0	18	1,604
Other consumers	13	-	-	-	8	21
Total	1,594	200	24	0	36	1,855

Table 2.1: Final energy consumption in 2022. Source: Ministry of Water and Energy (MoWE).

Domestic energy production and energy import

Ethiopia primarily relies on renewable energy sources for electricity, with hydropower contributing over 90% of the country's supply. Major ongoing projects such as the Grand Ethiopian Renaissance Dam (GERD, 5,150 MW) and Koysha Hydroelectric Power (1,800 MW) are critical in meeting growing demand. GERD is currently producing 2,350 MW and is planned to reach full capacity within a year. In addition to hydropower, wind farms such as Adama and Aysha contribute to the national grid. The country also has significant untapped solar and geothermal potential.

Biomass energy is entirely sourced from domestic resources, mainly fuelwood and charcoal. However, inefficient biomass use remains a challenge, contributing to deforestation and indoor air pollution.

Fossil fuel use has risen by 130% since 2011, increasing Ethiopia's dependence on imports and raising costs. In 2022, imported fossil fuels covered 11% of final energy consumption, up from 7% in 2011. The transportation sector is the primary driver of this rise, with demand more than doubling in the past decade.

Ethiopia also imports more than half of its coal demand, with import costs reaching $300 million annually. However, domestic coal production has grown, with about 40 small-scale producers covering 45% of national demand by 2022. Brown coal production is also emerging, reducing reliance on imports.

Forecast trends

Ethiopia's energy demand is expected to continue its upward trajectory, driven by population growth, urbanization, and industrial expansion.

- Electricity demand is forecasted to grow significantly, from 65 PJ (18 TWh) in 2023 to 202 PJ (56 TWh) by 2035 (both including losses), driven by electrification efforts and industrialization.

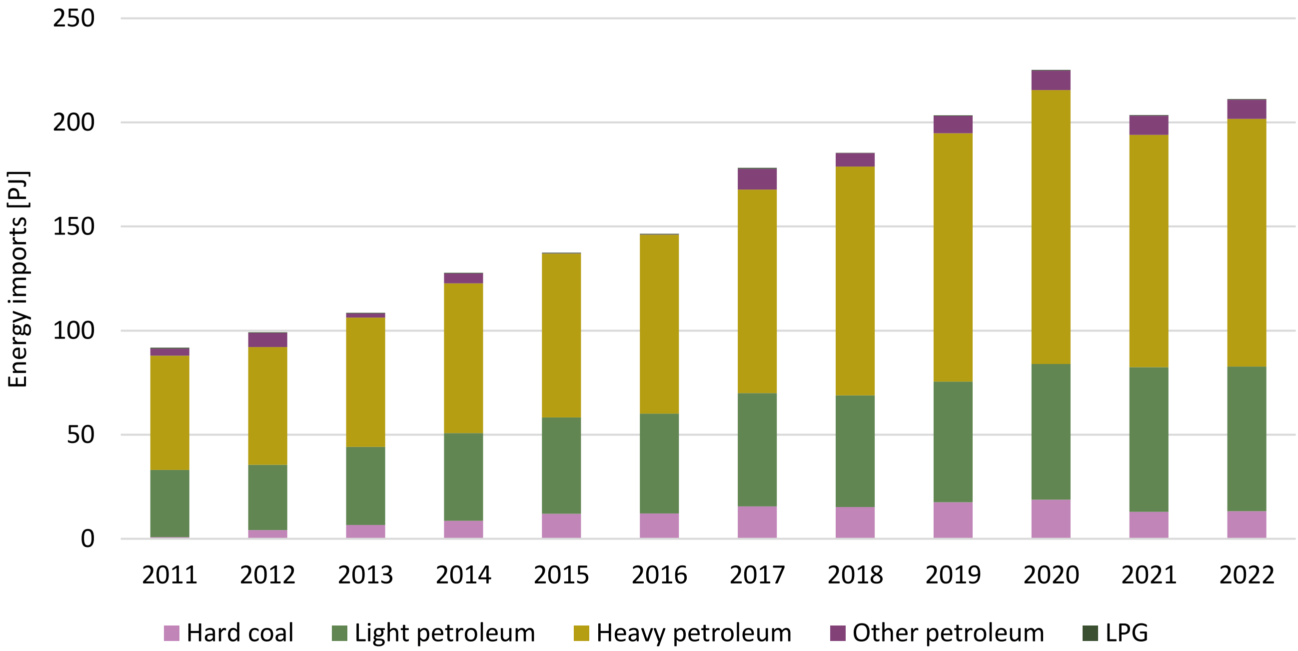


Figure 2.1: Energy imports by fuel in the period 2011-2022 (Petajoule, PJ). Source: Ministry of Water and Energy (MoWE).

- Transport sector energy demand is expected to increase due to rising vehicle ownership, although EV adoption and fuel efficiency improvements may gradually reduce reliance on imported oil. In 2024, more than half of all new person cars were EVs. It is estimated that 148,000 electric vehicles (government EV target) will consume 300 GWh/year electricity in 2030. This corresponds to 2% of the current electricity demand.
- Biomass consumption is likely to decline in relative terms as more households transition to modern energy solutions, though absolute consumption may remain high.
- Coal and natural gas usage will depend on domestic production capabilities, policy incentives, and import strategies. Currently there are no concrete plans for natural gas exploration.
- Ethiopia plans to utilise nuclear power as base load. However, the plans are in an initial stage.

2.2 Electrification

Expanding electricity access offers substantial environmental and social benefits, such as reducing deforestation and indoor air pollution by decreasing reliance on wood and charcoal for cooking and lighting. Electrification also bolsters climate resilience by promoting sustainable energy solutions

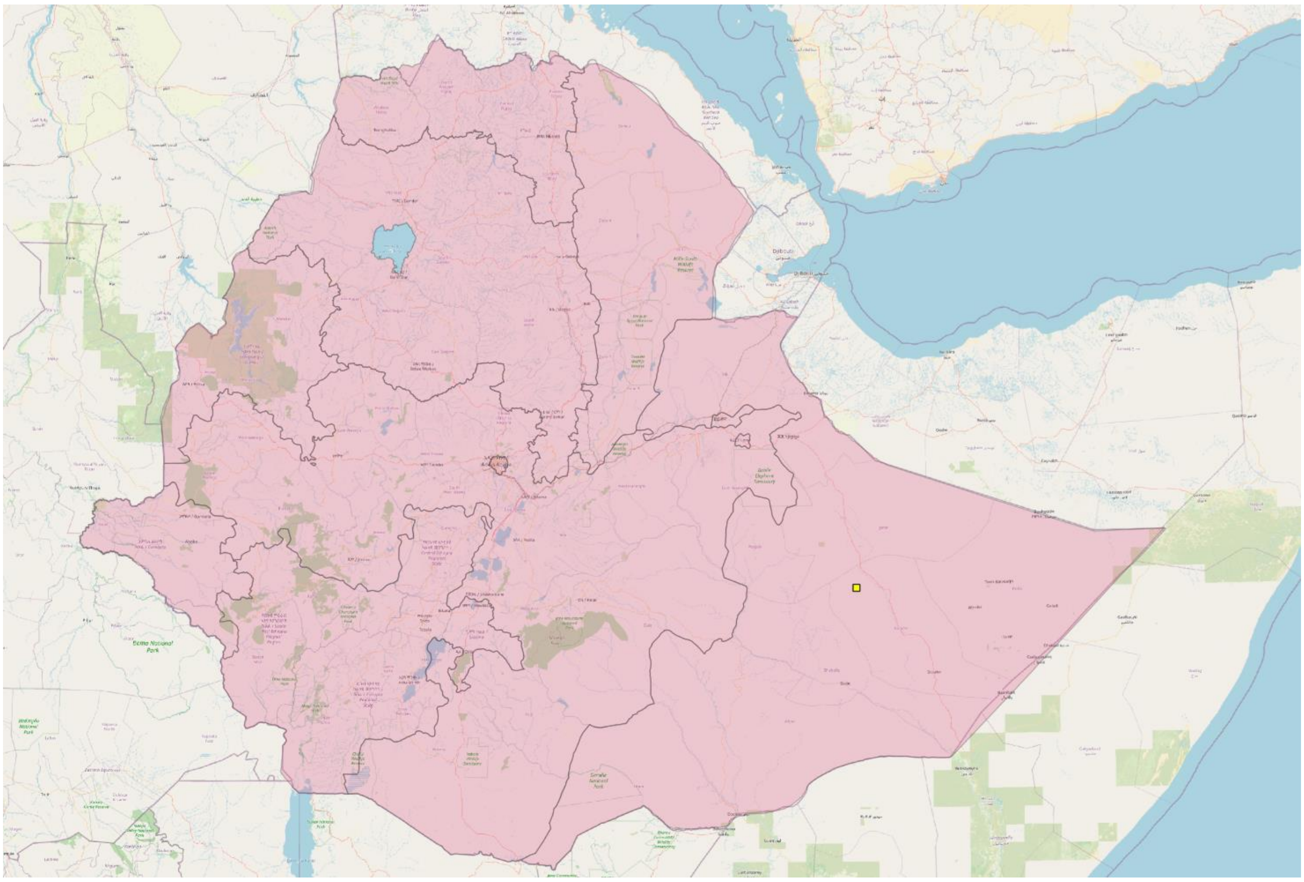


Figure 2.2: Illustration of the solar potential in Ethiopia and the required land area: A 108 km^2 solar PV park (the small yellow square placed in Somali region) would generate 18 TWh/year – the same as the current demand. In practice the area should be spread over the country. A similar generation from wind power would require 500 km^2 area.

and supporting the country's long-term development goals.

Reliable electricity transforms healthcare, education, and economic opportunities. Health clinics can store vaccines and operate life-saving equipment, while schools benefit from improved lighting and digital learning tools. Businesses and industries thrive with stable electricity, fostering job creation and economic growth. However, Ethiopia still faces major disparities in electrification rates between urban and rural areas.

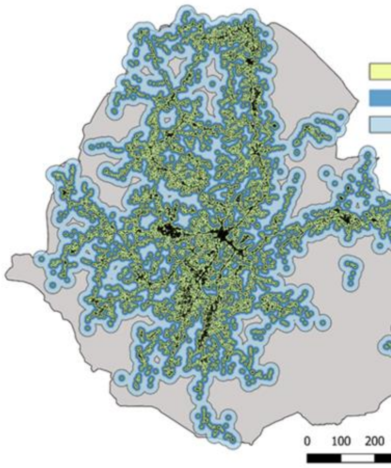
National grid access and disparities

By 2024, only 22% of Ethiopian households had a legal access to the national grid, with significant disparities between urban and rural regions. While Addis Ababa enjoys an electrification rate of nearly 93%, regions such as Afar and Somali remain below 12%. From 2019 to 2024, 2.2 million households were connected to the grid. Many still rely on shared, low-capacity connections, highlighting the need for accelerated electrification efforts, particularly for last-mile connectivity.

The National Electrification Program (NEP) in 2017, aimed for universal electricity access by 2025. NEP 2.0, introduced in 2019, set a goal to connect 65% of the population to the national grid while providing off-grid solutions for the remaining 35% by 2025. However, progress has been slower than expected due to financing gaps, regulatory bottlenecks, and underestimated infrastructure needs. The development of NEP 3.0 is crucial to revising targets, setting more realistic goals, and incorporating new technologies and funding mechanisms to accelerate progress.

The cost of electrification: Grid vs. off-grid solutions

Expanding the national grid is expensive due to the high costs of transmission lines, substations, and ongoing maintenance. 64% of Ethiopia's population lives within 5 km of existing grid infrastructure, making grid extension more cost-effective for these households compared to off-grid alternatives. 94% live with 25 km from the existing grid. Only in the Somali, Afar and Gambela regions more than 10% live 25 km or further from the grid. See Figure 2.3.



Distance to grid	Share of population
5 km	64%
10 km	82%
25 km	94%

Figure 2.3: Coverage of existing distribution grid.

In contrast, off-grid electrification solutions can be necessary for remote and dispersed communities where extending the grid is impractical and expensive. Small solar home systems, units that individual households could buy, can provide electricity to these areas.

While the cost of solar PV and batteries has been reduced, the total cost of minigrids is still noticeably high, with the battery being the costliest element. Levelized cost of electricity (LCOE) from minigrids is 33 USD cent/kWh or more, as opposed to 10 USD cent/kWh for electricity from the national grid. For minigrids, demand at night requires more battery capacity and is often limited for each household. In this way minigrids may not always deliver the same quality as the grid.

In NEP 2.0, it was suggested that minigrids could be used as a bridging solution, where a minigrid was constructed to give quick access to power, and after a few years (less than five years) the grid should be connected to the national grid. However, this is a very costly path and should be avoided. While the grid may continue to be used, the costly element of solar PV and battery will be an expensive overinvestment.

Expanding the national grid

Expanding the national grid has proven challenging due to high costs, infrastructure limitations, and slow connection rates. By 2024, only 22% of Ethiopian households had legal grid connections, with many relying on shared, low-capacity connections. At the current pace, only 27% of households are projected to be connected by 2030 - far below the National Electrification Program (NEP 2.0) target of 96%.

The Ethiopian Electric Utility (EEU) and Ethiopian Electric Power (EEP) have struggled with outdated infrastructure, frequent power outages, and high losses, further limiting access. While major hydropower projects like the Grand Ethiopian Renaissance Dam (GERD) are expected to boost generation capacity, weak transmission and distribution networks continue to hinder large-scale electrification.

Addressing last-mile connectivity challenges

Beyond infrastructure expansion, last-mile connectivity remains a critical barrier to universal access. Even in areas with existing grid infrastructure, many households remain unconnected due to high costs associated with service drops, poles, transformers, and household wiring. Addressing last-mile connectivity requires:

- Lowering connection costs through targeted (cross) subsidies and affordable financing for household wiring.
- Streamlining bureaucratic procedures to speed up the connection process.
- Ensuring that new grid extensions are accompanied by accessible service connections so that more households and businesses can benefit immediately from electrification projects.

Steps to accelerate grid expansion

- Strengthening transmission and distribution networks by investing in new substations, new transmission lines, and modern grid management systems to reduce power losses and improve reliability.
- Enhancing financial sustainability through electricity tariff reforms, improved revenue collection, and reductions in technical and commercial losses, which currently exceed 20%.
- Speeding up regulatory approvals for grid expansion projects by streamlining land acquisition, procurement, and permitting processes to prevent delays.
- Upgrading grid reliability and maintenance by modernizing outdated infrastructure, adopting predictive maintenance strategies, and improving service response times to reduce outages.

Achieving universal electrification

To achieve universal electrification, Ethiopia must adopt a comprehensive approach that prioritizes grid expansion while integrating broader energy planning strategies. Key policy and strategy measures include:

- Securing additional investment to strengthen distribution infrastructure and prioritize last-mile connections.
- Reforming electricity connection fees to better support low-income households while ensuring financial sustainability for the power sector.
- Encouraging local manufacturing of electrical components and stabilizing supply chains.
- Productive use of electricity should be a major driver for the electrification. Small businesses have a higher demand and are able to pay for the delivered power.

The need for a revised electrification roadmap

As Ethiopia seeks to accelerate its electrification efforts, the development of NEP 3.0 should be prioritized. The new plan must address the shortcomings of NEP 2.0 by revising targets, incorporating adaptive strategies, and ensuring robust funding mechanisms. The new plan should also place greater emphasis on improving grid efficiency, enhancing financial transparency, and strengthening institutional capacity to manage large-scale electrification efforts effectively.

A new World Bank programme, Accelerating Sustainable and Clean Energy Access Transformation (ASCENT), will contribute towards the achievement of universal electricity access. The programme plans to connect 600,000 households to the national grid (phase 1). However, much more is needed, as more than 15,000,000 households are waiting for a connection. Furthermore, expanding local and international partnerships will be crucial for securing additional funding, transferring technology, and sharing best practices. Ethiopia must also prioritize skill development within the energy sector to build a workforce capable of maintaining and operating an expanded national grid.

Without timely action, millions of Ethiopians may remain without reliable electricity for years to come, impeding economic growth, education, healthcare, and overall quality of life. However, with a well-executed strategy, Ethiopia can overcome these barriers and achieve its goal of universal electrification, unlocking new opportunities for social and economic transformation.

2.3 Electric vehicles

Ethiopia is actively promoting the adoption of electric vehicles (EVs) as part of a broader strategy to enhance energy security, mitigate climate change, and capitalize on its growing electricity generation capacity. With a heavy reliance on imported fossil fuels – costing the country over USD 4 billion annually – the shift toward EVs is not only an environmental imperative but also an economic necessity. Reducing dependence on fuel imports will alleviate pressure on foreign currency reserves while simultaneously curbing local air pollution and greenhouse gas emissions.

The growing adoption of EVs will affect Ethiopia's energy sector, particularly in terms of electricity demand and infrastructure development. A stable and sufficient power supply, combined with a well-planned and accessible charging network, is essential to ensuring a smooth transition. Recognizing these needs, the GoE has set ambitious targets, including a goal of 148,000 EVs (person cars) by 2030, and has introduced a series of regulatory reforms, tax incentives, and infrastructure initiatives to accelerate adoption.

Accelerating the adoption of EVs aligns with a global shift to reduce reliance on fossil fuels, combat climate change, and address the health hazards of urban air pollution. EVs are seen as a credible solution for sustainable transport, and favourable incentives and the declining cost of battery technology is making them a feasible option to users. As battery production scales up and efficiency improves, EV prices are expected to continue dropping, enhancing accessibility and accelerating their adoption. Ethiopia's transition to EVs reflects this global trend, positioning the country to benefit from both environmental and economic gains while fostering innovation in the local automotive and energy sectors.

Key policy and regulatory developments

To facilitate the transition to electric vehicles (EVs), the GoE has implemented a series of policies and incentives designed to lower the purchase price of EVs, making them more affordable and competitive. Additionally, these measures aim to promote local EV manufacturing and assembly and accelerate the development of essential charging infrastructure. Below are some of the key regulatory changes introduced to drive the adoption of EVs:

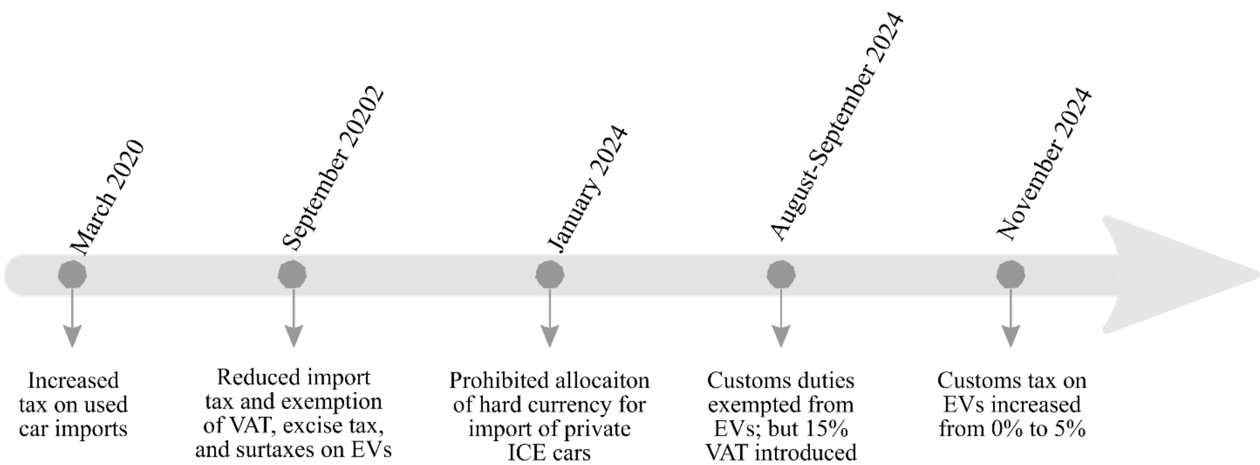
- *Proclamation on taxation of used car imports:* In March 2020, the country enacted a proclamation that imposed high customs taxes on used vehicles that are older than three years or travelled more than 4,000 km. By making older ICE vehicles less attractive for imports, this measure has effectively curbed the influx of used car imports, thereby paving the way for increased EV adoption.
- *Directive incentivizing EV imports*: In September 2022, Ethiopia issued a directive introducing significant tax exemptions and reductions to incentivize EV adoption. Following this directive, EVs become fully exempt from VAT, excise tax, and surtax, significantly lowering the cost of EV imports. Additionally, customs taxes have been reduced to 15% for fully assembled and 5% for semi-assembled EVs, while completely knocked-down vehicles (CKD) that are

assembled locally in Ethiopia are exempt from customs duties altogether to promote domestic manufacturing. This progressive tax regime is designed to incentivize both the import and local assembly of EVs. These incentives significantly enhance the attractiveness of EVs relative to ICE vehicles.

- *Prohibiting the allocation of hard currency for importing non-electric private vehicles:* As of January 2024, Ethiopia has effectively restricted the importation of ICE vehicles. While there is no formal legal or regulatory prohibition, the government has introduced stringent measures that make such imports practically unfeasible. These include prohibitively high taxes on used vehicle imports and a restriction on the allocation of foreign currency for importing ICE vehicles.
- *Introduction of VAT and revision of customs duties on EV imports*: A 15% VAT on EV imports was introduced in August 2024. About the same time, customs duties on EV imports were reduced to 5%. This revision is aimed at promoting domestic manufacturing and reducing reliance on imported vehicles. However, the higher overall import tax may also impact affordability, potentially slowing down the adoption and expansion of EVs.
- *Directive on public charging stations*: Recognizing the importance of a reliable, widespread charging network to support EV adoption, the government has introduced a directive outlining the regulatory framework for charging stations.
- *Public charging stations to be connected to the distribution grid:* As per the directive, charging stations will be connected to the distribution grid and are subject to tariffs for buying electricity applicable to general business.
- *Market-based pricing:* The directive mandates that EV charging prices be determined by market forces, ensuring competitiveness and attracting private-sector investment.

Additional actions and measures to accelerate EV adoption:

- Regulations on fuel-powered motorcycles: The government has begun restricting the use of fuel-powered motorcycles in Addis Ababa, pushing for an increased transition to electric alternatives.
- Public procurement practices guide the procurement of EVs rather than ICE vehicles, unless there is a concrete rationale to purchase the latter.
- Plans are underway to establish charging stations every 50 to 120 kilometres along major highways to facilitate long-distance travel.



- Electric buses are being introduced into urban transport networks, with an initial fleet operating in Addis Ababa.

Current situation

The most recent data from 2022 shows a total of 1.4 million vehicles in Ethiopia, whereof 290,000 were automobiles (cars). The vast majority (95%) of the cars were registered in Addis Ababa. In 2013 there were only 70,000 cars in the country, confirming a rapid growth in car imports over the last decade. See Figure 2.4 and Figure 2.5.

The vehicle fleet in Addis Ababa has experienced steady expansion in recent years, growing by an average of 15-20,000 cars per year.

In 2024 EV's represented more than 60% of all new cars. In just one year, the total number of EVs in Addis Ababa has tripled, growing from 4,600 in early 2023 to 14,000 in early 2025.

Projection of car fleet development

Based on trends in the car fleet and new vehicle registrations from 2020 to 2024, it is projected that the total number of cars in Ethiopia will continue to grow, increasing from just over 320,000 in 2024 to approximately 415,000 by 2030.

A key trend in this development is the increase of EVs. While EVs represent a small fraction of the fleet in 2024, their numbers are expected to grow steadily, reaching 113,000 by 2030 – accounting for nearly 28% of the total fleet. This shift is driven by government incentives, declining battery costs, and increasing consumer interest in EVs. Meanwhile, the number of internal combustion engine (ICE) vehicles is expected to gradually decline as older models are retired.

However, it is important to note that these projections are subject to uncertainty. The pace of EV adoption could be influenced by changes in government policy, shifts in global battery prices, improvements in charging infrastructure, and consumer acceptance of EVs. If incentives are reduced or supply chain challenges emerge, EV adoption may progress more slowly than anticipated. Conversely, stronger policy measures, increased local manufacturing, or technological advancements could accelerate the transition.

Advantages and disadvantages of EVs

The adoption of electric vehicles (EVs) in Ethiopia presents both significant opportunities and challenges. While the transition to EVs offers several economic, environmental, and social benefits, there are also obstacles that need to be addressed for successful implementation. Below is a summary of the key advantages and disadvantages of increasing the number of EVs in Ethiopia.

One of the most significant challenges in Ethiopia's push for EV adoption is the high initial cost of electric vehicles. Although government incentives like tax exemptions help reduce some of the costs, EVs remain expensive compared to traditional internal combustion engine (ICE) vehicles (especially used ICE cars). The price of cars is often out of reach for many Ethiopians, particularly in lower-income segments, where affordability is a primary concern. This financial barrier can limit the pace of adoption unless further subsidies, financial support, or financing options are introduced to make EVs more accessible.

Key actions to further accelerate electric vehicle adoption

To accelerate the adoption of electric vehicles (EVs) in Ethiopia, several strategic actions need to be prioritized. While some initiatives are already underway, key areas remain to be addressed to ensure a successful transition to a sustainable and energy-efficient transport sector. The following list outlines essential steps that should be taken to overcome existing challenges and scale up EV adoption across the country.

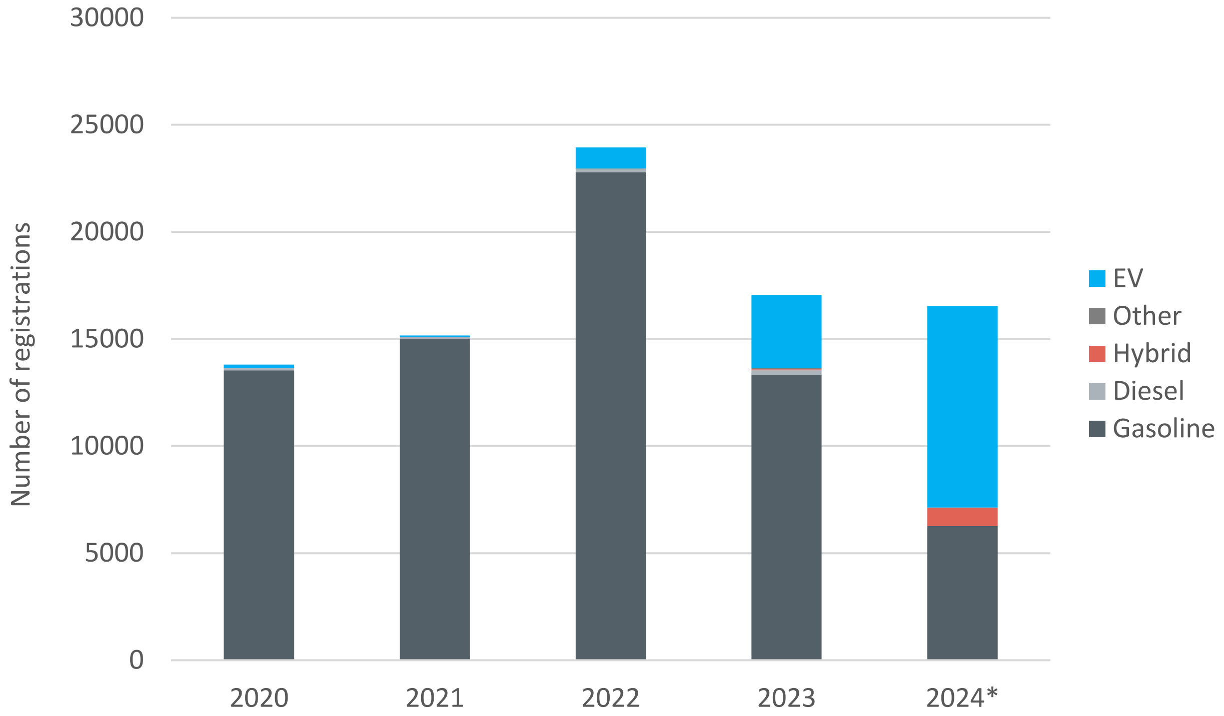


*Figure 2.4: New registrations of automobiles (cars) in Addis Ababa from 2020-2024. 2024 * Is estimated based on available data.*
Source: Addis Ababa Drivers and Vehicles Licensing & Control Authority.

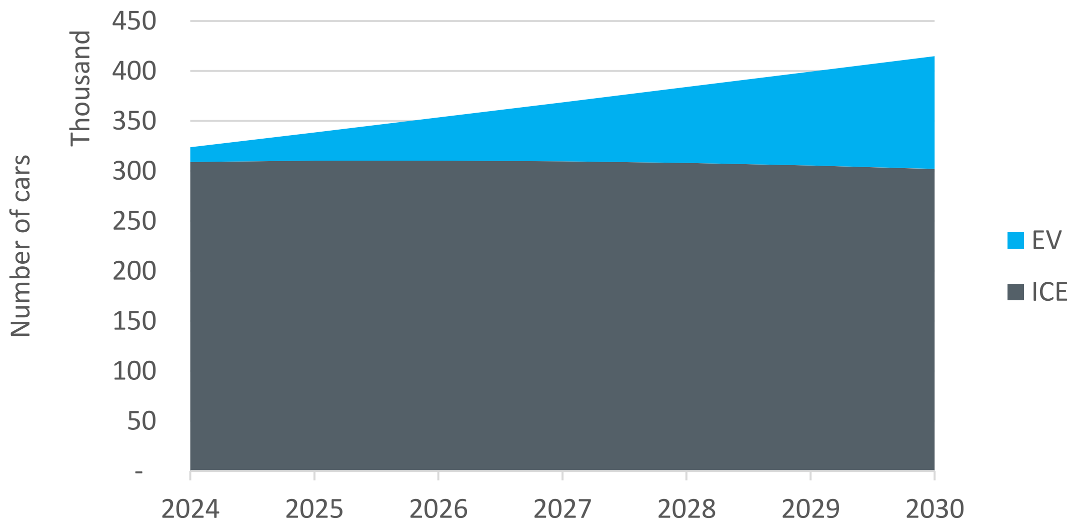


Figure 2.5: The figure illustrates the projected development of Ethiopia's car fleet from 2024 to 2030, distinguishing between internal combustion engine (ICE) vehicles and electric vehicles (EVs). Source: Own calculations.

Advantages	Disadvantages
Lower variable costs Electricity is currently cheaper than gasoline, leading to significant savings on operational expenses. By reducing the need for ICE cars, the importation of costly oil products will decrease, positively impacting Ethiopia's trade balance	**High upfront costs** EVs typically have higher initial costs compared to conventional cars, which can be a barrier for many consumers.
Higher energy efficiency EVs are three times more efficient than internal combustion engine (ICE) cars	**Limited infrastructure** Charging stations and EV maintenance facilities are currently underdeveloped, which could hinder EV adoption, especially in rural areas.
Use of hydro EVs can utilize the excellent renewable energy resources locally available in Ethiopia. As electricity for EVs are provided by clean hydro, introduction of more EVs will reduce greenhouse gas emissions and contribute to Ethiopia's emission reduction targets	**Maintenance** While EVs generally have fewer moving parts, specialized knowledge and infrastructure are needed for their maintenance, which may be lacking locally.
Energy security By reducing reliance on imported oil, EVs can contribute to greater energy security for Ethiopia, making the country less vulnerable to global oil price fluctuations	**Battery disposal and recycling** The environmental impact of battery disposal or recycling is a concern. Ethiopia will need to establish systems for safely recycling EV batteries to avoid long-term ecological damage.
Reduced air pollution and noise More EVs will improve the urban air quality and decrease noise levels in the big cities, contributing to improved life quality in cities	**Range limitations** Although EVs are improving in range, they may still face limitations in rural or remote areas where long distances between charging stations could cause "range anxiety" for drivers.

Infrastructure and technology development

- Develop public charging stations: Ensure widespread availability of public charging stations across urban and suburban areas, with fast-charging options at high-traffic locations and key routes.
- Develop Time-of-Use (TOU) tariffs to incentivize night-time charging and balance grid load. See chapter 4 about tariffs.
- Encourage local assembly and manufacturing: Promote the local production of EVs to reduce costs, create jobs, and stimulate innovation.
- Provide incentives for home and shared charging stations: Offer incentives to businesses and homeowners to install charging stations, particularly in urban settings. Promote shared charging infrastructure for apartment buildings and office complexes to encourage wider access.
- Enhance the reliability of power supply: Providing a continuous and stable supply of electricity will reduce the uncertainty associated with the limited driving range of EVs.
- Establish authorized importers, suppliers, and workshops.

Policy and market support

- Ensure consistent government policies: Develop long-term, stable policies and incentives to maintain momentum for EV adoption. See (MoTL and MoI, 2025).
- Electrify public transportation: Focus on electrifying public transport systems, particularly buses and taxis, to demonstrate the viability of EVs and reduce urban pollution. Provide incentives for private transport operators to transition to electric fleets.
- Foster a supportive business environment: Encourage private sector investment in EV infrastructure, including charging networks and vehicle leasing programs. If EEU enters the charging market, it should be carefully regulated so the market is still attractive for private investors.
- Implement a monitoring framework: Track the progress of EV adoption rates, growth of charging infrastructure, and grid readiness with a comprehensive monitoring framework. Regularly review and adjust policies based on technological advancements and evolving market conditions.

2.4 Biomass

In Ethiopia, biomass is a critical source of energy, particularly in rural areas where access to modern energy sources is limited. Biomass constitutes 86% of the total final energy demand in Ethiopia and the demand is estimated to increase with 2.4% p.a. In general, biomass is a renewable and locally available energy source, making it a vital resource for rural and urban communities. Its accessibility reduces the need for energy imports, supporting energy security and local economic stability. Biomass use also drives economic development by providing income and employment opportunities in rural areas where activities like charcoal production and wood collection are common livelihoods. Additionally, biomass energy promotes waste utilization, turning agricultural residues and animal dung into valuable resources. When managed sustainably, biomass can be carbon-neutral, contributing to climate change mitigation by balancing the carbon cycle through the absorption and release of CO_2. However, the use of biomass also poses significant challenges, particularly when used unsustainably.

- Environmental Impact: Unsustainable biomass harvesting, especially of fuelwood and charcoal, can lead to deforestation, soil erosion, and loss of biodiversity. This degradation reduces the land's ability to support diverse ecosystems, leading to desertification and declining agricultural productivity. In Ethiopia, where many areas are already vulnerable to environmental degradation, such impacts can exacerbate poverty and food insecurity. Deforestation is a critical environmental issue driven primarily by agricultural expansion, fuelwood collection, illegal logging, and infrastructure development. Over the past century, the forest cover in Ethiopia has decreased, exacerbating biodiversity loss, soil erosion, and water cycle disruption. The impacts extend to climate change, as deforestation releases significant amounts of carbon dioxide. Despite important efforts like the Green Legacy Initiative, which aims to restore forests through massive tree planting campaigns, challenges such as weak law enforcement, economic pressures, and climate vulnerability continue to hinder sustainable forest management.
- Health Hazards: Traditional biomass use in poorly ventilated spaces produces harmful smoke and pollutants, leading to respiratory diseases, particularly among women and children who spend more time near cooking areas. This is a significant public health challenge.
- Energy Inefficiency: Traditional methods of biomass use, such as open fires or rudimentary stoves, are inefficient, wasting a significant portion of the energy content. This inefficiency means that more biomass must be collected and burned to meet energy needs, leading to further environmental degradation and increasing the labour burden, especially for women and children responsible for gathering fuelwood.
- Carbon Emissions: While biomass can be carbon-neutral, inefficient burning or unsustainable harvesting can lead to net carbon emissions. If forests are not replanted after harvesting, the CO_2 released during biomass combustion adds to the atmospheric carbon load, contributing to climate change. The loss of forests also reduces the capacity to sequester carbon, accelerating global warming.
- Opportunity Costs: Using biomass, especially for energy, can divert resources from other essential uses, such as using animal dung as fertilizer. This trade-off can reduce soil fertility and agricultural productivity, leading to lower crop yields and increased food insecurity. In Ethiopia, where soil health is vital for food security, the opportunity cost of using biomass for energy can have significant economic and social impacts, perpetuating cycles of poverty.

The main types of biomasses used in Ethiopia include fuelwood, agricultural residues, animal dung, charcoal, forest residues and biogas.

Data about biomass use is very uncertain. Four pilot surveys have been conducted to improve data. Results from the survey of the four regions

(Sidama, Somali, Gambella and Dire Dawa) indicate that more than half of the households cook over an open fireplace, with only 22% of households using a manufactured stove, and 4% using electricity. Of the households that use a biomass stove, 64% have poor ventilation. Cooking is often carried out indoors with no exhaust system in the cooking space.

The average consumption of biomass is in the national statistics estimated to be 4 kg/household per day – and the four pilot studies support this estimation.

Biofuels

The term biofuel refers to liquid and gaseous fuels produced from biomass. Biofuels are commonly divided into first, second and third generation, but the same fuel can be classified differently depending on technology maturity. Emission balances or feedstock is used to guide the distinction. Bioethanol and biodiesel are the most produced biofuels, and are currently derived mainly from food crops such as maize, soya and sugarcane. Biofuels derived from food crops are known as first-generation biofuels. Second-generation biofuels include lignocellulose digestion, fast pyrolysis, and gasification technologies. These technologies suggest that a wide range of fast-growing, non-agricultural crops (or crop residues), including grass, algae or fast-growing trees, can be viable feedstock for liquid biofuels.

Ethiopia is one of the countries in Africa with the highest biofuel potential, and the government has proposed that about 23 million hectares of 'marginal' land be converted for biofuel feedstock production, mainly Jatropha Curcas.

Biogas

Biogas is produced through the anaerobic digestion of organic materials such as animal manure, crop residues, human waste, and municipal solid waste. This process generates methane-rich gas, which can be used for cooking, lighting, and electricity generation. The residual material, known as digestate, serves as a valuable organic fertilizer, enhancing soil fertility and agricultural productivity.

In Ethiopia, the potential for biogas production is immense due to the country's large livestock population, and substantial agricultural output. The estimated 65 million cattle, 40 million sheep, 50 million goats, and significant poultry numbers generate vast quantities of manure daily, which can be converted into biogas. Additionally, crop residues from staple crops like maize, teff, wheat, and barley contribute further to the biogas feedstock, while human and municipal waste from an increasingly urbanized population adds another layer of potential.

The combined biogas production potential from livestock manure, crop residues, human waste, and municipal solid waste in Ethiopia is substantial. Based on available data:

- Livestock Manure: The biogas potential from livestock manure alone is estimated to be 650 PJ of energy.
- Crop Residues: Crop residues (maize, sorghum, teff) could contribute an additional 200 PJ of energy.
- Human Waste: Human waste offers a potential of 21 PJ of energy.
- Municipal Solid Waste: Municipal waste could generate around 10 PJ of energy.

The total biogas potential of 880 PJ is close to 50% of the total biomass consumption in 2022.

Despite this significant potential, current biogas production in Ethiopia remains relatively modest. Biogas production is primarily focused on small-scale household digesters. It is reported there are currently 46,000 biogas digesters. The biogas sector is largely driven by government and non-governmental organizations promoting biogas as a clean cooking alternative.

Current estimates suggest that only a fraction of the total potential is being utilized, with less than 1% of the potential biogas being produced annually. This indicates that there is a vast untapped resource that, if fully harnessed, could play a crucial role in meeting Ethiopia's energy needs and supporting sustainable development goals.

Biodiesel

Biodiesel is a synthetic diesel-like fuel produced from vegetable oils, animal fats or recycled cooking grease. Biodiesel is produced through a process of transesterification from oils or fats and can be used in almost any diesel engine or mixed with conventional petroleum diesel. Pure vegetable oil can also be used in specially modified diesel engines. Biodiesel can be used directly as fuel, which requires some engine modification, or blended with diesel and used in diesel engines with few or no modifications. Biodiesel can be used as an additive to reduce vehicle emissions or in its pure form as a renewable alternative fuel for diesel engines. These materials contain triglycerides and other components depending on type. Some of the feedstocks used for biodiesel production are jatropha, castor, palm oil, coconut oil, canola oil, corn oil, and cottonseed oil, flex oil, soy oil, peanut oil, sunflower oil, rapeseed oil and algae.

Ethiopia also plans to reduce imported diesel through blending with biodiesel for vehicle fuel consumption. Its biofuel strategy has stipulated that biodiesel development should take place exclusively through the private sector, unlike its bioethanol investments. Despite the ambitious government strategy and the potential economic, environmental, and social benefits of biodiesel, the development of biodiesel in Ethiopia remains limited. The major reasons for the failure of the private sector to invest in biodiesel are the low feasibility of large-scale biodiesel projects, excessively high initial investment costs in marginal areas, low yields, lack of support from the local community, and a significant reduction of the incentives provided to motivate investment in biodiesel.

Ethanol

Ethanol is a clean indigenous energy source that in Ethiopia is produced as a by-product of sugar production. Today Ethiopia produces roughly 400,000 tonnes sugar annually and 21 million litres ethanol. Future expansion of sugar production could lead to additionally ethanol availability. Production has previously been used for blending into gasoline, but is now only used for industrial purposes, including beverage production for alcoholic drinks, pharmaceuticals as a solvent and disinfectant, cosmetics for products like perfumes and lotions, and as solvent in paint thinners and cleaning agents.

When blended with gasoline ethanol can create various fuel mixtures, such as E10 (10% ethanol, 90% gasoline), E15 (15% ethanol, 85% gasoline), and E85 (85% ethanol, 15% gasoline). These blends help reduce emissions, because ethanol burns cleaner than gasoline and has a higher-octane rating, which can enhance engine performance. Ethanol can support energy security by decreasing dependence on imported oil and boosting the agricultural economy. Most modern engines can use E10 without modifications, while higher ethanol blends require specialized vehicles. Overall, blending ethanol with gasoline offers significant environmental and economic benefits, contributing to a more sustainable fuel system.

In 2014/15, where most ethanol was blended in gasoline (12 million litres), it corresponded to a blend-in percentage of 3%. Today (2022) gasoline consumption has risen to 1.000 million litres annually. If all the available ethanol is blended in gasoline, the blend-in potential is 2,1%, reducing the gasoline imports by approximately 13 million USD.

2.5 Natural gas

Significant potentials of oil and natural gas are found in the Ogaden Basin, especially Calub and Hilala fields. Ethiopia has proven reserves of natural gas of at least 2,800 PJ (2.6 trillion cubic feet). According to Ministry of Mines, this reserve is estimated to be enough to be used for fertilizer, power generation and different petroleum products for more than 50 years. Currently these potentials are not further investigated.

A project consisting of extracting natural gas and connecting the field in Ogaden with a 767 km long gas pipeline to Djibouti has been cancelled (in

2022). In the project, the natural gas production was planned to be 460 PJ/year (25% of the current total final energy demand).

The Ministry of Mines is now exploring a new project with a focus on domestic use, e.g. production of fertilizer. The ministry also expresses interest in working with Ethiopian Electric power (EEP) to integrate natural gas into electricity generation. Power production from natural gas may be used to balance the power system in dry years. In a dry year the Ethiopian hydro plants get 20-25% less water than in a normal year. It may be a challenge to accommodate such a variable demand in a future natural gas project.

Ethiopia is dependent on imported petroleum products with current costs in excess of $4 billion annually. As a result, the government of Ethiopia is in the process of implementing a strategy for developing, processing and using the country's natural resources to offset imports. The policy will focus on natural gas exploration and prioritize development of the sector to open the area for companies and to encourage investments.

Natural gas reserves	Trillion cubic feet *(TCF)*	Energy equivalent *(PJ)*
Proven	2.6	2,800
Probable	1.9	2,000
Possible	2.3	2,400
Accumulated	*6.9*	*7,200*

Table 2.2: Natural gas reserves as of June 30, 2024. Source: Ministry of Mines (MoM).

3. Security of Supply

In recent years, Ethiopia's power system has faced increasing challenges in maintaining a stable electricity supply. Frequent power interruptions have several negative consequences, such as:

- Disruptions in production and delays.
- Limited benefits for end-users who rely on a stable electricity supply.
- Increased reliance on alternative resources like biomass during outages.
- Investment in costly backup generators by some end-users.
- Revenue loss for the Ethiopian Electric Utility (EEU) and Ethiopian Electric Power (EEP) due to unfulfilled supply.

Ethiopia's transmission grid, managed by EEP, operates at multiple voltage levels: 500 kV HVDC, 500 kV, 400 kV, 230 kV, and 132 kV, with a total route length of 20,634 km. Ethiopia's transmission system is interconnected with neighbouring countries including Djibouti, Sudan, and Kenya.

On the distribution side, EEU operates at 66 kV, 45 kV, 33 kV, and 15 kV.

3.1 Introduction to security of supply

Security of supply refers to the degree to which electricity is reliably available to end-users. It encompasses two key features:

Adequacy: This is the ability of the generation and grid infrastructure to meet the electricity demand. In Ethiopia, as in other countries relying heavily on hydroelectric power, the occurrence of dry years can challenge adequacy. *With a growth rate of approximately 10% per year, Ethiopia must double its generation and grid capacity every seven years to meet demand.*

Security: This refers to the system's resilience in the face of sudden failures. Many blackouts are caused by cascading failures - one issue (e.g., a tripped transmission line) can overload another line, causing it to trip as well. Without efficient protection systems, such cascading failures can lead to widespread blackouts. A key operational rule is the N-1 principle, which ensures the grid can continue operating even after the failure of any single component. However, parts of the Ethiopian transmission grid lack sufficient redundancy to operate according to this rule.

Maintaining transmission grid stability involves:

Energy Balance: In a synchronous system, electricity generation and demand must always be balanced. Ethiopia is synchronously connected to Djibouti and Sudan. If demand exceeds supply, the grid frequency drops. Automatic reserves monitor the frequency and correct any deviations. The standard grid frequency is 50 Hz, with acceptable deviations of +/- 0.5 Hz. Frequency is a global feature in the synchronous system.

Voltage Control: Voltage levels must be kept within acceptable limits to prevent system disruptions. Over-voltage can trigger protection systems, resulting in disconnecting of transmission lines. Voltage is a local feature dependent on the power flow, load conditions, and grid topology.

Operate the system in a N-1 safe mode

EEP has identified several key N-1 elements in the transmission grid, including important lines like Koka-Gelan (230 kV) and Sululta-Markose (400 kV), as well as transformers like the Bahir Dar 400/230 kV transformer.

Ethiopia is a relatively small synchronous system (18 TWh) which makes balancing supply and demand more difficult. Even with interconnections to Sudan and Djibouti, total system demand remains under 50 TWh, which is small compared to larger systems, such as continental Europe's, which is 3,000 TWh. In larger systems, the impact of a single failure (N-1 incident) is less significant, and the need for reserves is proportionally smaller, providing more system robustness.

Ethiopia is connected to Kenya with a DC line. Currently this line is used for export, but it is under investigation if and how the line could also be used for short term balancing (ancillary service, primary reserves).

Statistics on power interruptions

EEU statistics from users with a smart meter show 39 interruptions per month, with an overall duration of 21 hours (3%). Households, which are typically connected to the low-voltage distribution grid, experience more frequent interruptions than industrial users.

The data from EEU's smart meters for industrial customers shows significant variation, with interruptions more frequently in the wet season.

There have been four major blackouts in recent years: November 2020, April 2021, March 2024 and December 2024. The blackouts lasted 2-3 hours. The 2020 blackout caused by a failure in Sudan and the 2021 event linked to a test in the Sodo II converter station. The December 2024 outage was caused by heavy winds and falling trees impacting the Dedisa line. The cause of the March 2024 blackout is unknown. The black-outs illustrate that the Ethiopian system is still not N-1 robust. A N-1 robust system can absorb any large, single error without losing customers.

Interruptions often result from earth faults, short circuits, and overcurrent, which are exacerbated by environmental, infrastructural, and operational challenges. During the rainy season, high humidity and moisture degrade insulation, increasing the likelihood of leakage currents and faults.

3.2 Actions to improve the security of supply

Transmission side improvements:

- Grid expansion and redundancy: Expanding Ethiopia's transmission grid and reinforcing existing lines will help Ethiopia better cope with rising demand and prevent widespread outages. Building new transmission lines and interconnecting with neighbouring countries, such as Kenya, Sudan, and Djibouti, will provide greater flexibility and backup during supply disruptions. This interconnected system enhances system stability and can offer backup during emergencies.

- Advanced protection systems: Upgrading protection systems using high-speed relays, digital fault recorders, and automated protection schemes will minimize the impact of faults. These systems will quickly isolate problems, reducing the risk of cascading failures and large-scale outages. Real-time fault detection and predictive maintenance capabilities will also enhance grid stability.
- High-voltage direct current (HVDC) systems: Investing in HVDC transmission systems will improve the efficiency of long-distance power transmission and offer greater control over power flows. HVDC will reduce transmission losses, stabilize voltage, and enhance the integration of renewable energy sources, providing grid resilience in case of failures.

Distribution side improvements:

- Smart grid and digitalization: The adoption of smart grid technologies, including smart meters and real-time monitoring systems, will enable more efficient, reliable, and flexible electricity delivery. Smart meters will allow operators to track consumption, improve billing accuracy, and adjust supply based on real-time data. Furthermore, consumers will benefit from dynamic pricing and better control over their energy use.
- Automated reconfiguration and fault detection: Automating the distribution network with real-time fault detection and reconfiguration systems will ensure a quick restoration of service after outages. When a fault occurs, automated systems can reroute power to unaffected areas, minimizing downtime and preventing cascading failures.
- A more flexible distribution network, such as a mesh or ring configuration, would improve system resilience by offering multiple power paths and reducing reliance on a single route.
- Demand response programs: Incorporating demand response technologies on the distribution side will allow consumers to adjust their electricity usage during peak demand periods. Through dynamic pricing or incentives, EEU could better manage electricity consumption, alleviating pressure on the grid during critical times.
- Data-driven decision making: The collection and analysis of consumption and operational data will allow grid operators to predict demand more accurately, optimize grid performance, and improve asset management. Data analytics and machine learning will enable predictive maintenance.
- Rehabilitation of existing networks: Infrastructure development projects, such as the Corridor Project, provide excellent opportunities to rehabilitate the current grid. These projects leverage synergies between infrastructure developments and improvements in the distribution grid, enhancing reliability, increasing capacity, reducing losses, and extending access to electricity.

4. Electricity tariffs

Electricity tariffs play an integral role in shaping the energy landscape as they directly affect social equity, the attractiveness of the energy sector for private investment, the financial health of utilities, user behaviour towards energy saving, and the adoption of alternative energy sources.

Although tariff regulations mandate cost-reflective pricing, electricity tariffs have historically remained low due to infrequent adjustments and affordability concerns. Additionally, the impact of the 2018 tariff increases has been significantly eroded by persistent inflation in recent years. As a result, utilities have experienced severe financial strain, limiting their ability to mobilize sufficient funds for infrastructure expansion and service improvements. To address this challenge, the latest tariff reform increased tariff rates approximately fourfold over a four-year period starting in September 2024.

Despite this substantial increase, tariffs may still fall short of full cost reflectivity, especially given persistently high inflation, pointing at the need for potential further adjustments.

Also from September 2014, 15% VAT has been applied for households with a demand over 200 kWh/month.

4.1 Tariff setting and structure

Updating tariffs begins with utilities conducting a tariff study, which serves as the foundation for proposed tariff adjustments. The findings are then reviewed by the Petroleum and Energy Authority (PEA), which provides recommendations for approval by the Council of Ministers. Once approved, the revised tariffs are implemented by the utilities. Additionally, tariffs for certain demand categories - such as those under Power Purchase Agreements (PPAs) - are established through contractual agreements. According to the Tariff Guidelines, electricity tariffs must cover the prudently incurred costs of supplying electricity to end users while also considering affordability and other public development objectives.

Tariffs are structured based on consumer type and usage level. Residential tariffs follow a tiered system, where rates increase with higher consumption. The current seven-tier residential tariff structure starts with the lowest rate for basic consumption (up to 50 kWh per month) and progressively increases, reaching the highest rate for usage exceeding 500 kWh per month. The lower tariff rates for basic consumption help ensure affordability for low-income households.

As per the Tariff Guidelines, electricity tariffs shall be adjusted every fourth year to reflect changing economic circumstances. Since 2006, tariffs have only been adjusted twice. The first adjustment, taken into effect in 2018, involved gradual tariff increases particularly for commercial users and residential customers with higher consumption bands. In nominal terms, the average tariff for residential customers doubled over the four-year period, with customers within lower consumption bands experiencing relatively lower increases. For industrial customers, the average tariff increment was 88%. However, despite the nominal increase in tariffs, the real impact of the tariff adjustment was relatively limited due to the high inflation.

The 2024 tariff reform introduced a gradual increase in tariff rates over the next four years. The gradual increment is intended to make the adjustment more manageable for households already burdened by the rising cost of living. The adjustment aims to better reflect the true cost of electricity supply and enhance the financial sustainability of the utilities. The revised tariffs, taken into effect in September 2024, involve an average 10% increase in tariff rates on a quarterly basis. In addition to the tariff adjustment, VAT was recently introduced on electricity prices, thereby increasing the final tariff payable by end-users.

General business rates are projected to rise from approximately 2.12 ETB/kWh to nearly 10 ETB/kWh by the end of the reform period.

- Household tariffs: See Figure 4.1.
- Service and commercial sectors: These sectors will see moderate increases in their tariffs. Service sector tariffs will be increased from 2.11 ETB/kWh in 2024 to 9.8 ETB/kWh by 2028.
- Higher tariffs have been introduced for high-voltage industries, which are the largest consumers of electricity. The tariff for high-voltage industries will be increased from 1.36 ETB/kWh in 2024 to 2.80 ETB/kWh by 2028.

The tariff adjustment plan includes several key elements that will assure a gradual transition to cost-reflective electricity pricing:

- Quarterly tariff increases: Over the next four years, electricity prices will rise steadily towards a cost recovery level. The target is to achieve full cost recovery by 2028, with most end-user categories facing a tariff increment of approximately 10% per quarter.

- Time-of-Use (ToU) tariffs: There are plans to expand the use of smart meters and pilot projects for time-based electricity pricing. Full implementation of time-of-use tariffs, which vary based on the time of day, is expected to be introduced by 2026 for large industries and commercial users.

- Review of PPAs and export tariffs: Tariffs for large industries and export agreements will be periodically reviewed to ensure competitiveness, especially as Ethiopia looks to strengthen its role as an electricity exporter in East Africa.

4.2 Challenges and implementation considerations

While these reforms are well-structured, there are potential challenges that could arise during implementation. Resistance from certain sectors, particularly those facing significant tariff hikes, may lead to pushback or calls for slower increases. Moreover, the complexities of phasing out broad subsidies and replacing them with targeted ones could complicate the reform process, especially if the transition is not well-managed. It will also be crucial to ensure that the implementation is transparent and that stakeholders are kept informed to minimize public dissatisfaction.

There could be concerns about the affordability of electricity for vulnerable populations amidst rising living costs and inflation. Therefore, a strong communication strategy and the careful management of targeted subsidies will be key to maintaining public support for the reforms.

These tariff adjustments are expected to bring significant long-term benefits to Ethiopia's electricity sector:

- Financial sustainability: The introduction of cost-reflective tariffs will help stabilize the finances of EEP and EEU, providing a stable revenue stream for infrastructure expansion and maintenance.
- Improved service quality: With more adequate funding, the quality of electricity service is expected to improve, reducing the frequency of power outages and enabling a more reliable supply.
- Encourage private investment: The new tariff structure will make Ethiopia more attractive to private investors in on-site generation, e.g. by solar power.
- Index-linking tariffs to exchange rate and the general price level: The high inflation may require tariff setting mechanisms that allow appropriate updates vis-à-vis the general price level and exchange rate. Such a mechanism is in line with the tariff guidelines and can be linked to or combined with the four-year tariff adjustment plan.

Hydropower costs range from 3-5 cents per kWh, and wind and solar costs are between 5-7 cents per kWh. These cost structures align with Ethiopia's

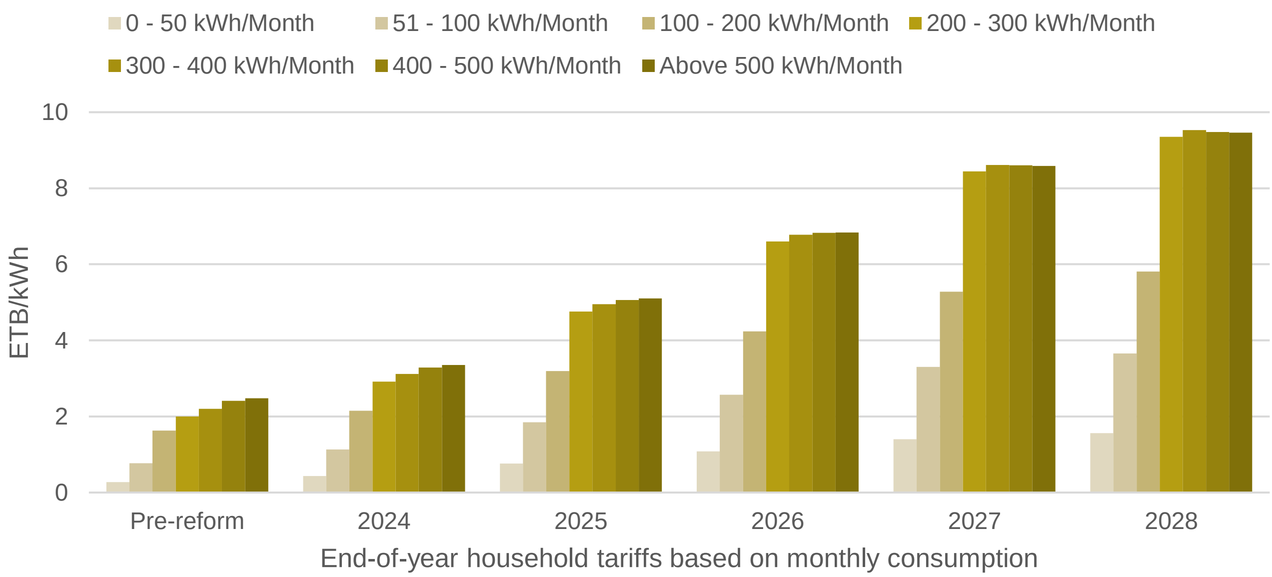


Figure 4.1: End-of-year household tariffs based on monthly consumption

export tariffs to Kenya, which are priced at USD 6.5 cents per kWh.

Currently, there are practically no roof-top solar PV systems in Ethiopia. With the planned increase in the tariff, many households and businesses may find it attractive with small individual solar PV systems. Individual solar PV systems will often send power back to the grid, e.g. during mid-day, where generation is high, and demand may be low. EEU should prepare for this, e.g. preparing grid codes for such systems and prepare meter requirements for bi-directional power exchange. Just paying for the net-demand (demand minus export) may be too attractive, as it represents a use of the grid as a free battery.

While recent tariff adjustments will move tariffs toward cost recovery, part of the proposed increment is likely to be eroded by the high inflation rate and the decline in the value of local currency. This can be mitigated by implementing an automatic tariff setting mechanism that allows appropriate updates vis-à-vis the general price level and currency exchange rate. This will ensure that the real value of proposed tariffs remains at the desired level irrespective of fluctuations in the general price level and currency value.

Timely implementation of tariff adjustments in accordance with the guidelines is crucial to reducing the financial strain on utilities, ensuring cost recovery, and maintaining the long-term sustainability of the electricity sector.

Consideration should be given to ensuring that tariff changes do not slow down the pace of electrification. Additionally, affordability concerns will have to be addressed, particularly regarding potentially higher, market-based tariffs for off-grid systems, to ensure that electricity remains accessible to all households, especially low-income and rural communities.

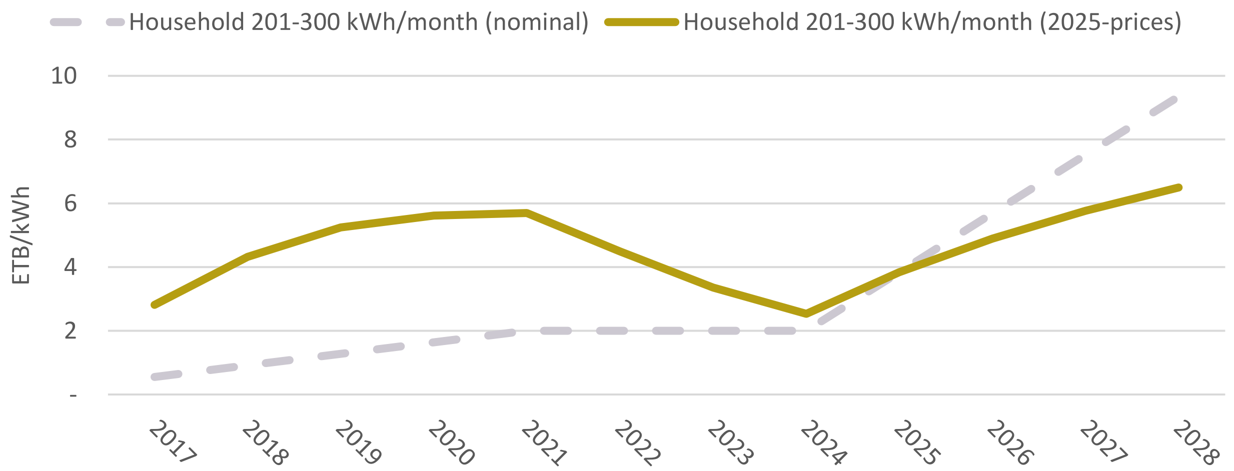


Figure 4.2: Historic and future average household tariff (across all tiers) in 2025-prices (inflation adjusted) and nominal values.

5. Utility Restructuring

With the Home Grown Economic Reform Agenda: *The Power Sector Reform*, four taskforces has been established:

- Financial Viability
- Energy Security
- Operational Performance and Structural Reforms
- Energy Access

The aim of the taskforces is to address the challenges faced by conventional power systems and to investigate and formulate a spectrum of solutions.

The focus of this chapter is to further the perspectives of the organisation of the power sector in Ethiopia.

5.1 Current organisation

In 2013, Ethiopian Electric Utility, EEU, and Ethiopian Electric Power, EEP, were created out of former vertical integrated utility, EPPCo. EEU manages distribution and is a main implementer of the electrification of Ethiopia, whereas EEP owns and operates all generation (hydro and wind power) as well as the transmission grid. Grids of 66 kV and below is EEU, above is EEP. Trans border connections to Sudan, Djibouti and Kenya are also operated by EEP. Both institutions are state owned, and act as regulated monopolies.

In the future, when new generation, organised as independent power producers, IPP, starts producing, EEP will act as a single wholesale buyer.

While the grids (transmission and distribution) can be considered *natural monopolies* (you will have two competing grids) other parts of the power sector do not share that nature, as different generators can compete over delivering power. This is the case both in a planned system (as the current Ethiopian) as well as in more market-based systems.

When Eastern African Power Pool, EAPP, becomes operational, competition will gradually be introduced into the Ethiopian system.

5.2 Independent Power Producers, IPP

The Government's plan is that most new generation should be IPP. The use of IPP's can activate private capital and may also introduce competition.

Currently, auctions are planned for two solar PV sites: Gad and Weransso. The auctions will determine who will require the cheapest Power Purchase Agreement (PPA), and the constructed plants will be privately owned and will sell the electricity to EEP.

Additionally, two IPP auctions are planned for wind power (Aysha and Debre Birhan).

The planned setup will give the IPP's a fixed payment for multiple years. It can be noted that when a power market is developed, a different setup can be used: The IPP can sell the power to the market and can compete over who can accept the lowest mark-up on top of the market price. Eastern African Power Pool, EAPP, is expected to start operating in 2025, however it is unknown when a competitive market price will be achieved. Until such a time, EAPP will be a possibility alongside existing systems, and the liquidity of the market may remain low – as seen in the Southern African Power Pool, SAPP.

A set-up with a mark-up on top of the market price will give the investor more risk and remove some risk for the EEP/the government.

5.3 Development of TSO

A transmission system operator, TSO, owns the transmission system and is responsible for the system operation (control room) and may also be responsible for the development of grid codes and market rules.

Today, EEP is both a generator and a TSO. With a significant share of IPP generators, this may not be the best way to organize the system operation. When the TSO needs to curtail generation, e.g. due to grid constrains, doubt can arise whether this is done in a neutral way.

In the European Union, EU, the internal market directive requires that competition is free and fair for all countries. A member state is not allowed to favour own producers. The result is that generators from all member states compete in the day-ahead market – and national generators do not have precedence in the market. In Europe, this has been a main driver for high liquidity and strong competition. The African Union, AU, are promoting a similar single market, however the timeline for implementation in the power sector is unknown.

5.4 A more focused DSO

EEU is the Distribution System Operator. Key functions are billing customers, operating the distribution grid and developing and maintaining the distribution grid.

Currently, EEU has also been given the responsibility of developing 100 micro grids. This task is not a key DSO activity, and it could be considered to place this task in a dedicated organisation.

Operation of EV charging stations could be handed to the private sector, buthaving both private actors and the DSO in the market may undermine the private sector.

In Kenya a rural electrification agency exists. They are responsible for expanding the grid and connecting new customers. After connecting customers, the grid is handed over to the DSO. This set-up give transparency about the funding needed for electrification. A similar transparency may be achieved by clearly separating the funds used for electrification.

6. Power Sector

This chapter analyses which type of generation should be invested in and examines the prospects for power exports. The analyses are based on detailed modelling of the power system in Ethiopia and 13 neighbouring countries.

A separate report documents the assumption and the detailed results.

6.1 Introduction to Ethiopia's power

The Ethiopian power sector is developing rapidly. In the coming years, more households will be connected to the national grid and the productive use of electricity will increase in agriculture and industry. New demand types will develop e.g. related to EVs and data centres. The power sector must therefore serve increasing domestic demands going forward, while ensuring security of supply and observing strategic goals regarding regional trade of electricity.

The current generation capacity (as of March 2024) is 4.3 GW, comprising 3.9 GW hydropower and 0.4 GW wind power. An additional 6.4 GW is under construction and is planned to be fully available by 2027, bringing the capacity to 10.7 GW.

Currently, cross-border interconnections from Ethiopia extend to Sudan (200 MW), Djibouti (150 MW), and Kenya (400 MW) with a total capacity of 750 MW. As the available capacity for Kenya increases to 1,200 MW, the total capacity will increase to 1,550 MW.

Targets for the sector are to diversify the electricity mix, to comprise at least 25% non-hydro RE generation[2] by 2030, and to strengthen regional co-operation for cross-border energy export.

This chapter investigates the least-cost development of Ethiopian power system under different policy, economic development, and trade scenarios. 13 nearby countries in east Africa (Figure 6.1) are included to analyse prospective social welfare gains, which cross-border trading could bring about in Ethiopia and the region. The analysis has been carried out in Balmorel, a detailed techno-economic model which utilises linear programming to determine (optimise) least-cost investments in power generation and interconnector capacity (Ethiopian Energy Outlook 2022).

6.2 Scenario definition

Scenario analysis is conducted to gain insight into the Ethiopian power system – and the potential costs and benefits of the alternative futures until 2040. Each interest area is developed as a theme for scenario study, namely - the policies, economic development, and trade.

The Reference scenario is the least cost scenario with no policy restrictions and is developed as a baseline for all other scenarios. The assumptions for the Reference scenario represent the most likely projections and expectations.

Figure 6.1: Model Area.

For each of the themes, critical factors and uncertainties which could influence the future are identified to develop scenarios. The driving factors for the scenarios are related to Ethiopian national policies on the power sector, focusing on diversification of resources and export, demand growth, generation and transmission expansion, and costs of financing.

6.3 Key findings and insights

This section focuses on the results from the reference scenario, and the conclusions across the themes. Scenarios are indicated in Figure 6.2.

Capacity development in the Reference scenario

The focus of this section is on which additional generation is relevant – on top of the existing and under-construction capacity.

Least-cost expansion of power generation capacity in Ethiopia results in investment in hydro, solar, and wind power, as can be seen in Figure 6.3. Large-scale hydropower investment occurs in the medium term (3,198 MW by 2034). 2030 is considered the first year in which large-scale hydropower plants can be made operational, due to relatively prolonged construction periods compared to other technologies.

In the intervening period until 2030, the staged commissioning of the Grand Ethiopian Renaissance Dam (GERD) will be the main source of increasing generation capacity, supplemented by small endogenous investments in both wind power (60 MW) and rehabilitation of capacity at existing hydro plants.

Investment in the aforementioned large scale hydro plants, comprising Beko Abo (935 MW), Genji (214 MW), Geba 2 (157 MW) and Upper Mandaya (1700 MW) is the main driver of capacity expansion, and consequent net electricity export from Ethiopia, in the medium term. It is highly recommended to give the feasibility studies for the plants an update and secure that they are bankable – including high quality social and environmental

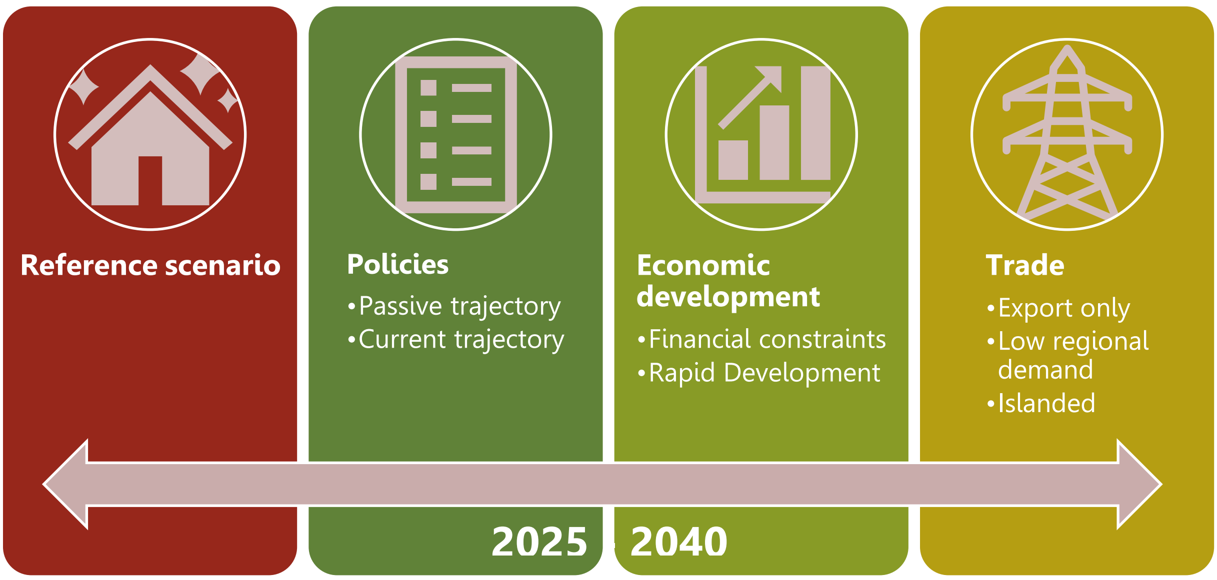


Figure 6.2: Power outlook themes and corresponding scenario.

studies. Only well-documented projects can expect to be financed by international institutions.

In the longer term, once the most attractive hydro sites have been exploited, and due to continued solar power cost reductions, investments in solar power will dominate new capacity. The share of solar in electricity generation reaches 17% in 2040.

International trade in the Reference scenario

Ethiopia's net electricity exports until 2036 will primarily be driven by large-scale hydropower investments. However, net import of electricity is expected from 2038, as the pace of demand growth in Ethiopia exceeds that of supply, in the least-cost development. See Figure 6.4. Trade agreements should therefore facilitate reduced net export from Ethiopia over time. Kenya is consistently Ethiopia's leading trade partner.

To enable optimal trade, ensuring the Kenya–Ethiopia (KY-ET) interconnector operates at full capacity (1200 MW) by 2030 should be a priority. No expansion is planned for the existing interconnector capacities with Djibouti (150 MW), Kenya (1,200 MW), or Sudan (200 MW). However, new interconnections are planned with Eritrea (42 MW), Somalia (51 MW), Somaliland (7 MW), and Yemen (240 MW), further enhancing Ethiopia's capacity to balance power generation and supply within the region.

Conclusion and recommendations

The early deployment of large-scale hydropower at multiple sites in Ethiopia should be prioritised. Investments in hydropower serve as the key driver of electricity exports in the medium term, thereby providing a source of foreign currency.

Revenues generated from export can subsequently be reinvested in Ethiopia, e.g. to support further

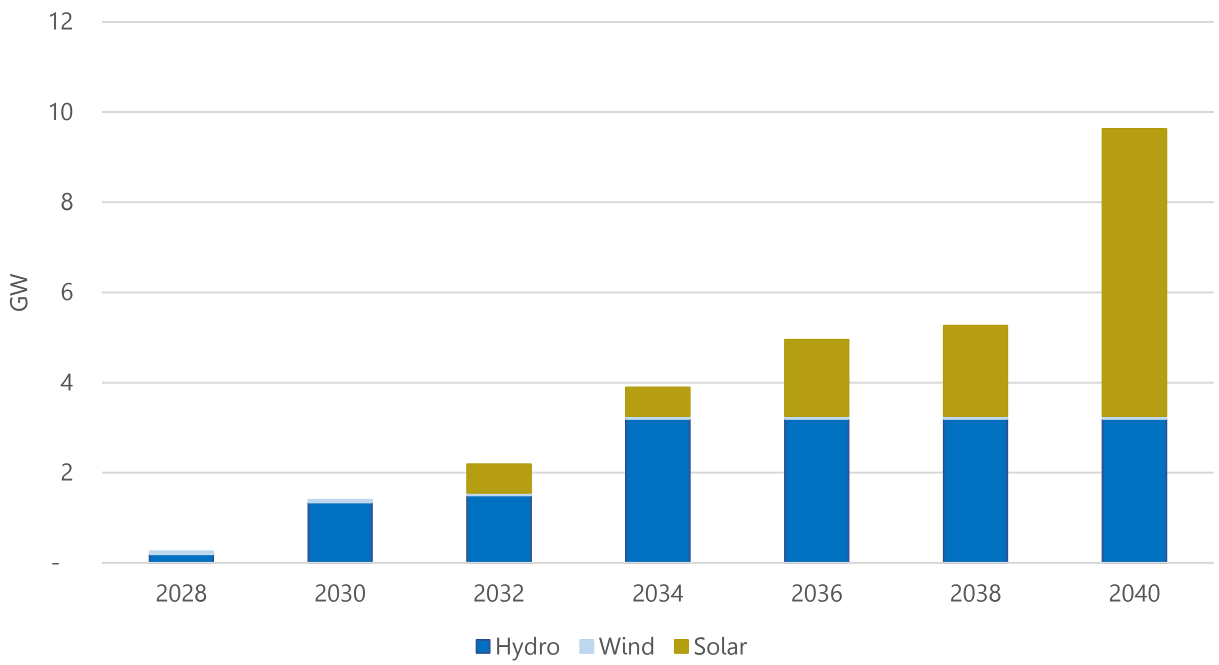


Figure 6.3: Ethiopia new capacity investment in Reference scenario.

electrification, thus stimulating demand growth and reducing the country's reliance on exports over time. Growth of demands from other, non-convention sources, e.g. adoption of electric vehicles (EVs), reduces the risk of curtailed electricity.

In the longer term, declining costs make solar photovoltaic (PV) technology increasingly competitive with the best Ethiopian hydropower sites. By 2040, solar energy is projected to account for 17% of the electricity generation mix, which remains below the diversification target. This is considerably lower and later than the diversification target of 25% by 2030. Flexible operation of hydropower plants should be considered the main enabler of increased solar power penetration. Further, co-location of solar power at existing hydropower plant sites could significantly reduce the grid infrastructure investments required to enable solar power integration.

Electricity trade is an important aspect of strategic development of the sector, while strengthening the overall profitability of the electricity sector. Trading power with neighbouring countries lowers total system costs and generates foreign currency revenue, but it also increases exposure to external markets/foreign actors. However, fixed export strategies, while supporting energy security, imposes additional system costs and increases reliance on foreign markets. To maximize cross-border synergies between renewable resources, flexible interconnector operations should be prioritized.

Electricity trade should be based upon marginal-cost pricing, through dynamic and cost-reflective tariffs. This ensures fair pricing for trade partners while promoting efficient electricity distribution. Moreover, maximizing the utilization of renewable resources through electricity trade is essential for reducing regional emissions. If trade is restricted,

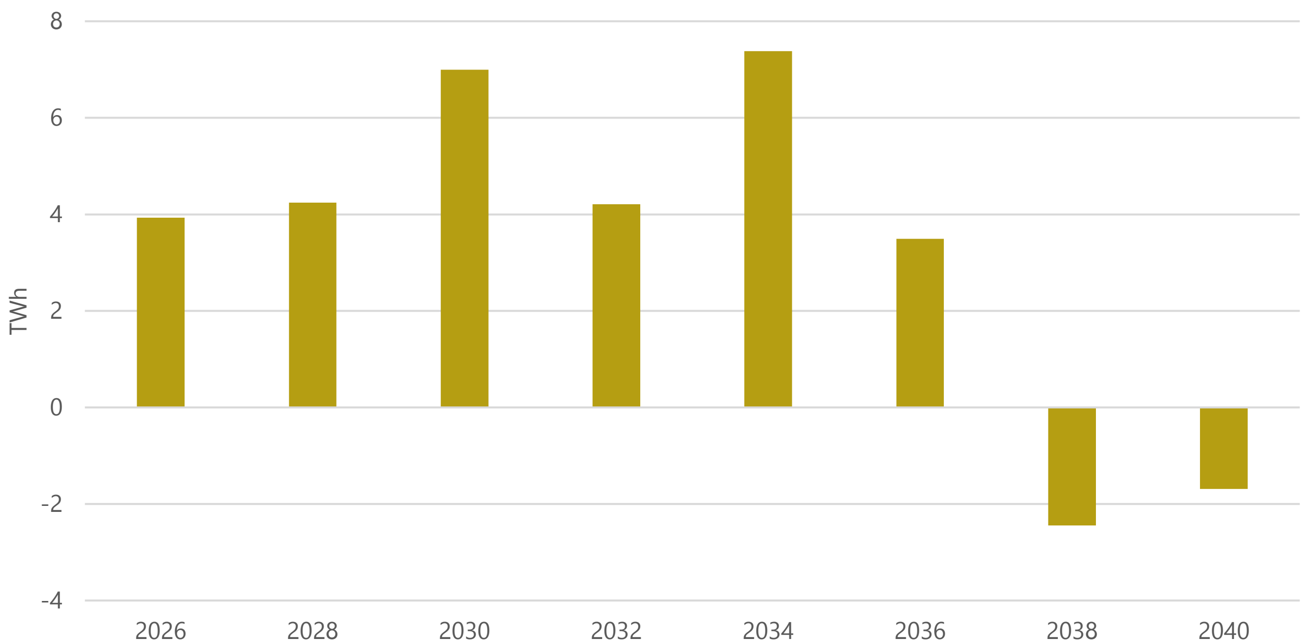


Figure 6.4: Net export in (TWh) in the Reference Scenario.

regional emissions may increase due to a continued reliance on fossil fuels in neighbouring countries. By enhancing renewable integration and prioritizing efficient power trade, Ethiopia can strengthen its energy sector's long-term stability while contributing to regional decarbonization efforts.

Ethiopia's on-grid power supply is free of emissions. Ethiopian export enables CO_2 emission reductions within the region. Regional emissions are exacerbated if trade is limited - it results in the highest regional emissions. Thus, Ethiopia can offer emission-free electricity to help lower the emission factor of the region.

Updating feasibility studies is required as a prerequisite for hydro plant investment to ensure long-term sustainability and profitability. International financing of big hydro projects requires high quality documentation of social and environmental consequences of the projects., including any cross-border impacts.

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