

ANALYZING UGANDA'S ENERGY SECTOR

Term paper for ESL100

By

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Undertaking by the Student

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Table of Contents

Abstract	4
Basic Information.....	4
Locally Available Energy Resources	5
Imports of Energy	6
Refining/Conversion Infrastructure	6
Cost of Energy Carriers.....	7
Electricity Generation Capacity	8
Local Capability.....	9
Nuclear Energy.....	9
Energy Demand Trends	10
Energy Balance	10
Greenhouse Gas Emissions	11
Pollution Status.....	12
Global Commitments	13
Progress in Renewable Energy Deployment.....	13
Policy Measures	14
Conclusion and Recommendations	15
Citations.....	16

Abstract

This report provides a thorough analysis of Uganda's energy sector, addressing current challenges and proposing future strategies. The study highlights Uganda's dependence on biomass, limited rural electrification, and environmental degradation, highlighting the urgent need for diversification, infrastructure enhancement and policy implementation. Emphasizing the importance and scope of renewable energy, it advocates for a holistic approach, integrating economic, social, and environmental factors. By identifying the research gaps in the current energy scenario, this report aims to contribute valuable insights to the field.



Basic Information

Development Indicator	Latest Figure	Year
Population, total ^[1]	47,249,585.0	2022
GDP (current US\$) ^[1]	45,559,202,048.7	2022
Poverty headcount ratio at national poverty lines (% of population) ^[1]	20.3	2019
Unemployment, total (% of total labour force) (national estimate) ^[1]	3.4	2021
Average energy consumption per capita (BTU) ^[2]	2,943,000	2019
% renewables in total energy supply ^[3]	94	2020
% biomass in renewable energy supply ^[3]	99	2020
Human development index ^[4]	0.525	2021
Total energy supply per capita (TOE) ^[5]	0.400	2020

Uganda, situated in East Africa with a population of approximately 47 million, faces economic challenges despite its GDP of around \$45 billion. With a poverty rate of 20% and an unemployment rate of 3.4%, the nation struggles to provide widespread access to quality education and healthcare and improve poverty levels. Energy consumption remains relatively quite low, with per capita electricity usage at about 2.9MMBTU, as opposed to 304.4MMBTU in USA. While the total energy consumption is dominated by renewables, the majority share is of traditional biomass sources since the start. Uganda's Human Development Index (HDI) 0.5, reflecting moderate human development. Energy intensity, measured at 0.4 tonnes of oil equivalent per capita, highlights the need for enhanced energy efficiency. These figures underscore the importance of targeted policies to improve living standards, promote education, ensure sustainable energy access, and foster economic development.

Locally Available Energy Resources

Uganda possesses abundant renewable energy resources, making it a potential hub for clean energy production. Due to the country's geographic location near the equator, solar, wind, geothermal energy offer promising prospects, with ongoing studies and projects exploring their feasibility for large-scale energy generation. The discovery of significant oil reserves has also opened new avenues, although the extraction rate is currently limited.

Currently, biomass, due to its widespread availability, is used extensively for direct household needs and hydropower, due to several rivers and water bodies in the country, is used vastly for electricity generation.

Energy Source	Estimated Electrical Potential (MW)
Hydro	4137
Geothermal	450
Biomass cogeneration	1650
Solar	200
Peat	800
Wind	Yet to be determined
Total	7237

[6]

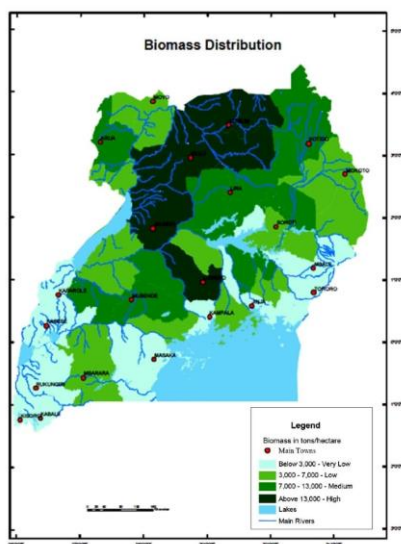


Figure 8. Map showing the biomass sites country-wide in Uganda. Data obtained from Ref. [33]

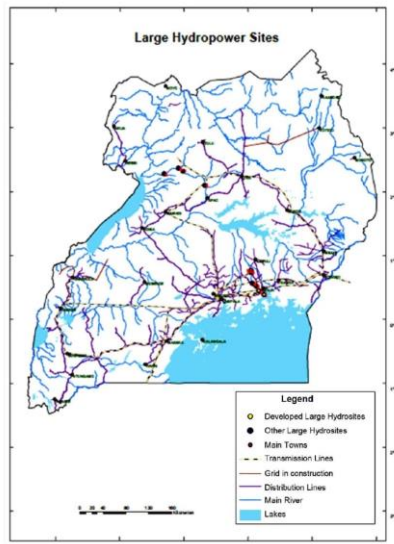


Figure 7. The identified large hydropower sites country-wide in Uganda. Data obtained from Ref. [33]

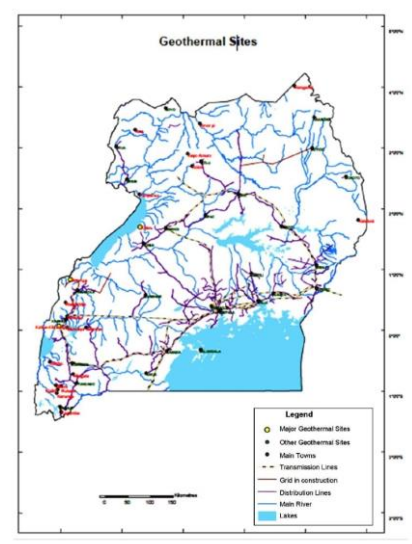


Figure 6. Map showing the identified geothermal sites country-wide in Uganda. Data obtained from Ref. [33]

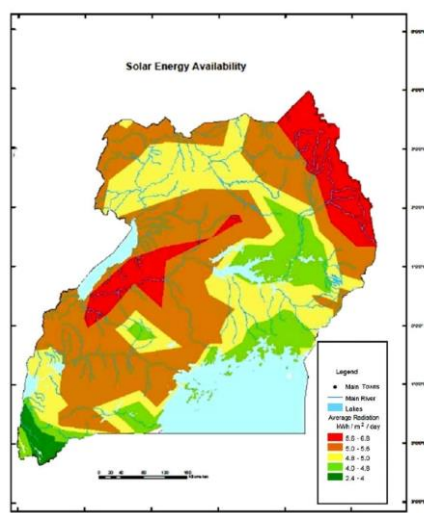


Figure 5. Map showing the availability of solar energy for different sites across Uganda. Data obtained from Ref. [33]

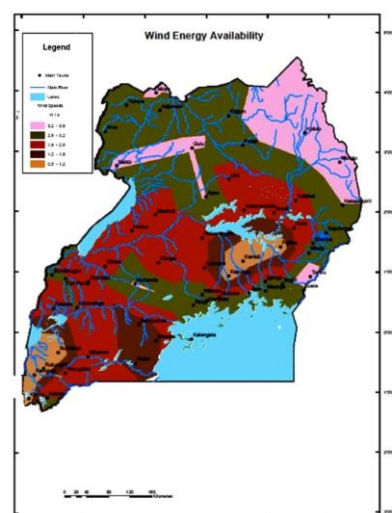
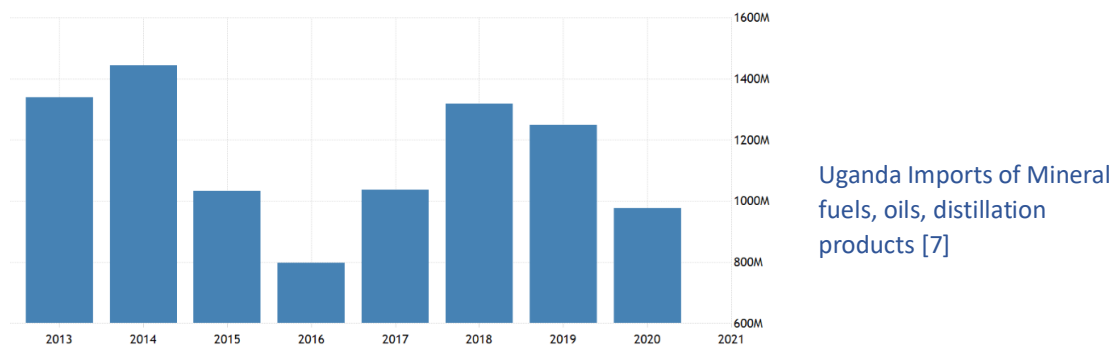


Figure 4. Map showing the availability of wind energy for different sites across Uganda. Data obtained from Ref. [33]

[17]

Imports of Energy

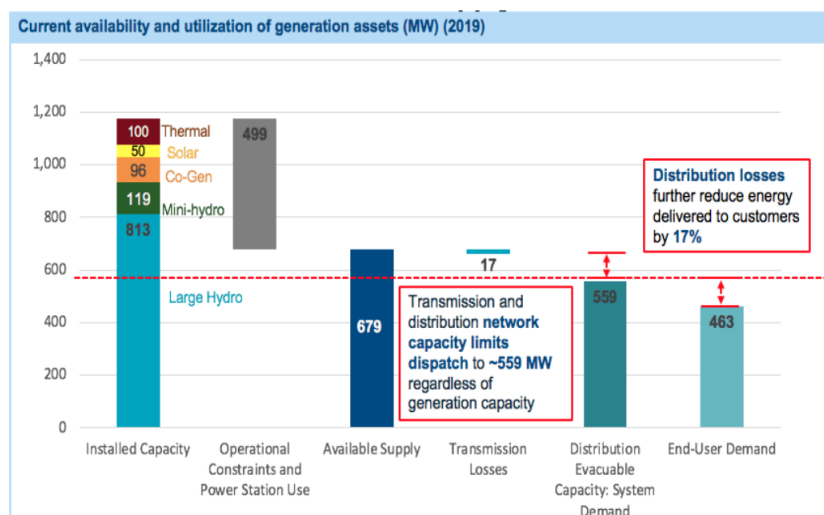
Uganda does not produce crude oil domestically in substantial quantities, leading to a complete reliance on oil imported from neighboring countries to fuel its transportation sector. Additionally, Uganda also imports electricity during periods of high demand or natural calamities destroying the country's electricity generation plants. 20% of total energy consumption is met by imports [3]. Diversification into renewable energy and enhancing energy efficiency are essential strategies to reduce pressure on its foreign exchange reserves and ensure long-term energy sustainability.



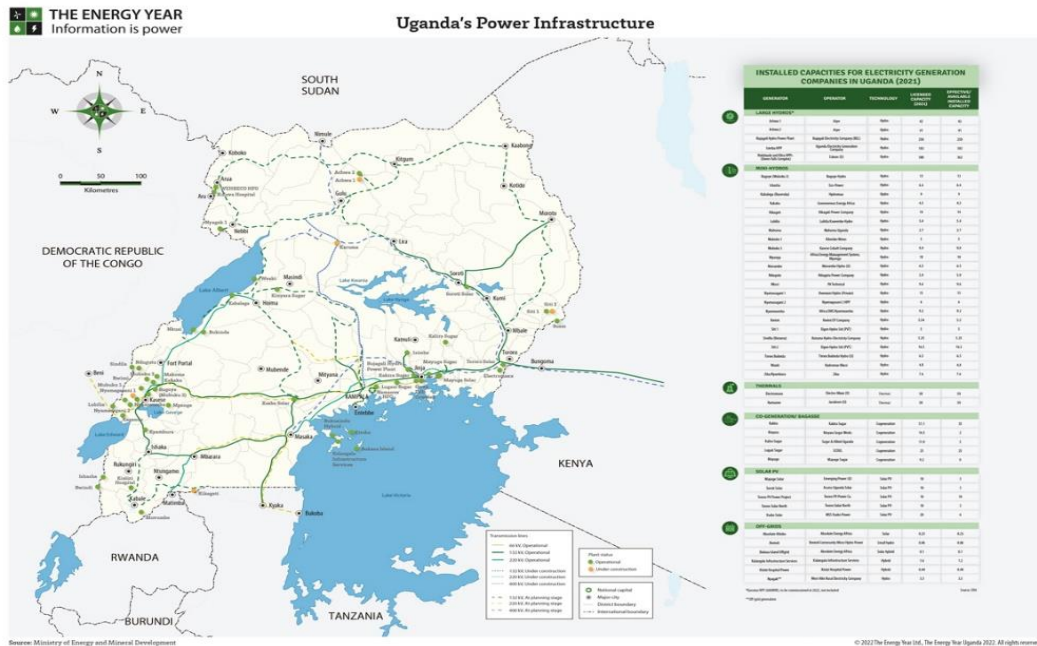
Refining/Conversion Infrastructure

Uganda's fossil fuel refining and renewable energy conversion infrastructure is very limited, creating a gap between the available and extractable energy. Moreover, insufficient and ineffective transmission and distribution networks further create a gap between extracted and received energy.

Uganda's energy infrastructure includes its first oil refinery in Hoima, designed to reduce petroleum imports. The country has a network of fuel distribution facilities and is investing in solar, wind, and biomass conversion infrastructure. Mini-grids and standalone systems, often solar-based, are deployed in rural areas. Efforts are ongoing to integrate renewable energy into the national grid through converter stations and smart grid technologies, promoting energy diversification and accessibility.



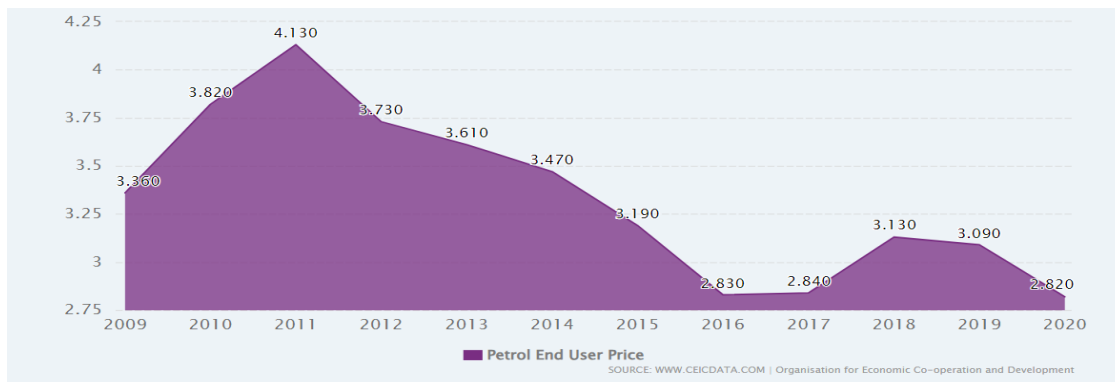
[8]



[21]

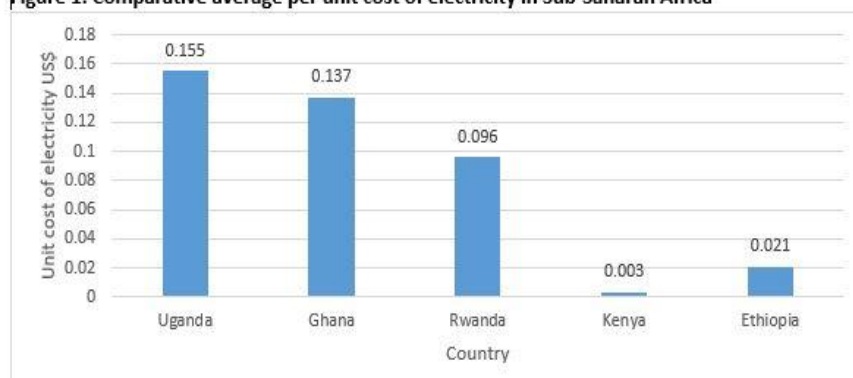
Cost of Energy Carriers

Petroleum products have high cost and experience maximum fluctuations due to international oil price changes, as crude oil is fully imported. Electricity tariffs although more stable, are affected by hydropower generation costs and user category. Moreover, Uganda has one of the highest electricity tariffs in Africa. Biomass is relatively quite cheap due to ready local availability. Government policies and subsidies aim to stabilize prices, but occasional fluctuations are inevitable due to external market forces.



[9]

Figure 1: Comparative average per unit cost of electricity in Sub-Saharan Africa



[22]

	Uganda	Delhi
Petrol	Rs.120.54/litre	Rs.96.72/litre
Electricity	Rs.17.81/unit (domestic)	Rs.7/unit (800-1200 units)
Biomass	Rs.1332/tonne	Rs.6000/tonne

Electricity Generation Capacity

Uganda's electricity generation capacity predominantly relies on hydropower, especially major plants like Bujagali and Kiira. Moreover, Uganda has started investing in renewable sources, mainly solar. These efforts, coupled with rural electrification initiatives and off-grid solutions, align with Uganda's commitment to sustainable development, diversification, and universal electricity access. However, there is still a wide gap between the installed capacity and end user energy, as can be seen from the chart alongside.

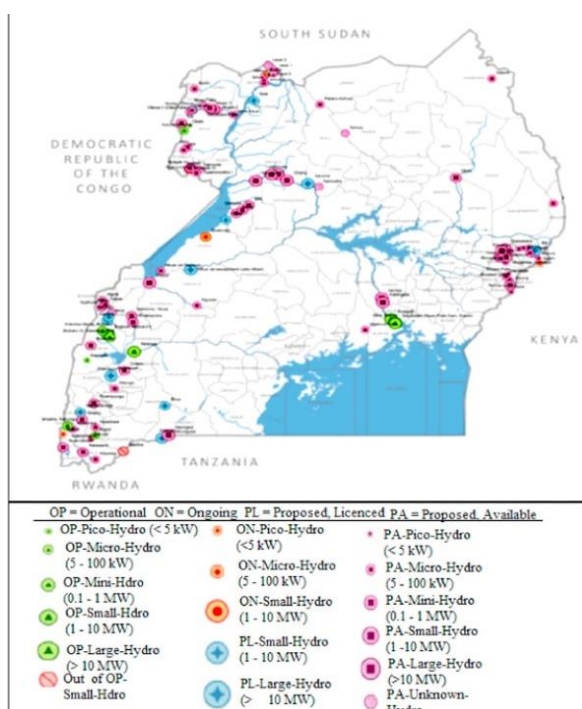


Table 1.0: Current State Of Power Generation In Uganda

Plant/Source	Capacity (MW)
Kiira hydro power station	200
Nalubaale hydro power station	180
Bujagali hydro power station	250
Mpanga small hydro power plant	18
Bugoye small hydro power plant	13
Mobuku III hydro power plant	10.5
Tronder Ishasha hydro power plant	6.5
Nyagak III hydro power plant	3.5
Kakira Cogeneration plant	22
Kinyara cogeneration plant	8
Namanve thermal power plant	50
Electro maxx	20

[18]

Local Capability

Uganda has made significant strides in developing local expertise within its energy sector to reduce dependence on imports and non-renewables. Briquette manufacturers offer biomass with high energy densities and lower emissions than traditional fuel. Contractors have been extensively building dams to harness maximum hydropower. Local universities provide specialized training and government provides incentives and collaborations with international organizations to bolster local capabilities in modern energy technologies.

Moreover, as per a survey in 2015-16 ^[10], Uganda has been ranked as the most entrepreneurial country in the world, driven extensive innovation in solar and biomass technologies.



Nuclear Energy

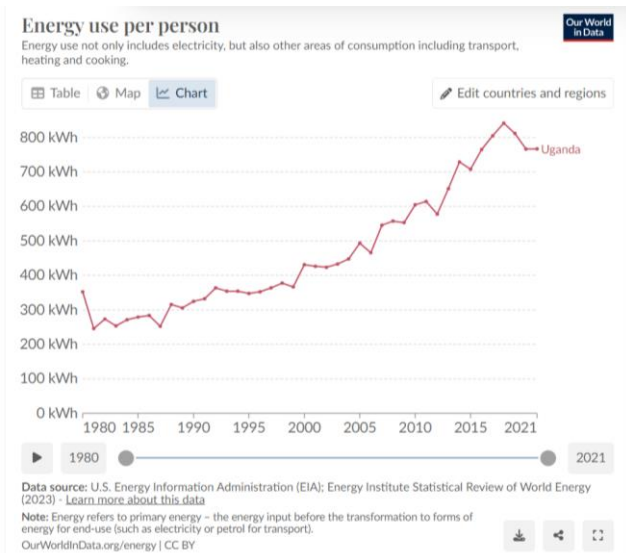
Uganda has not constructed or operated a nuclear reactor till date. But the President and the Energy and Minerals Minister recently claimed that Uganda has Uranium deposits and they expect to start generating at least 1GW from nuclear power by 2031. The first nuclear project, Buyende Nuclear Power Plant, would be located at Buyende, 150 km north of the capital Kampala.



Energy Demand Trends

Uganda's energy demand is escalating at a notable pace. With a population growth rate exceeding 3% and the urbanization rate currently at 5.4% annually, energy needs intensify in rapidly expanding cities. The industrial sector, accounting for about 25% of Uganda's GDP, demands a substantial energy supply, while rural electrification efforts have reached over 1.5 million households. Moreover, the transport sector, a significant consumer, experiences a rising demand for fuels due to increased economic activities. ^[1]

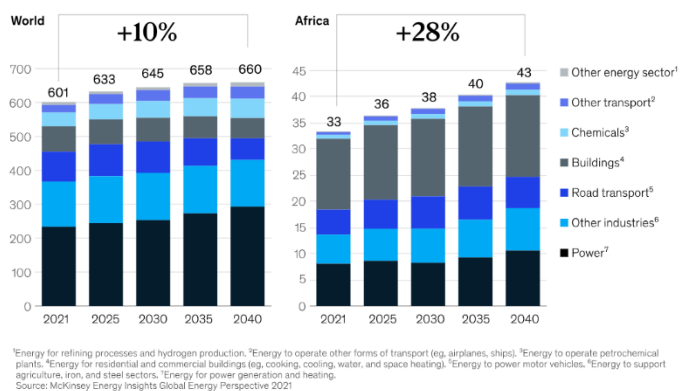
In the near future, similar to other developing countries, Uganda's energy demand is expected to increase by as much as 30%.



[11]

Africa's energy demand in 2040 could be 30 percent higher than it is today, compared with a 10 percent increase in global energy demand.

Primary energy demand by industry, million terajoules



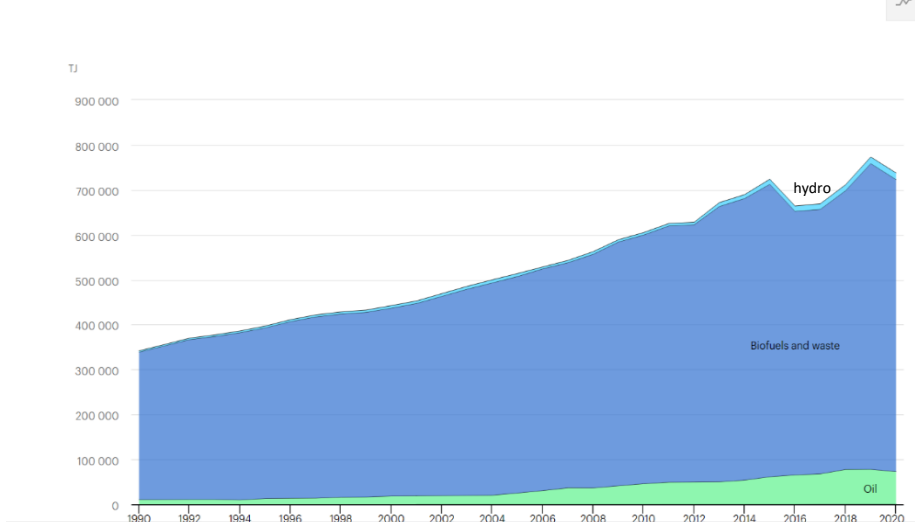
[23]

Energy Balance

Despite abundant renewable energy resources, biomass remains the primary energy source for direct household energy needs like cooking and heating. While 94% of the total energy

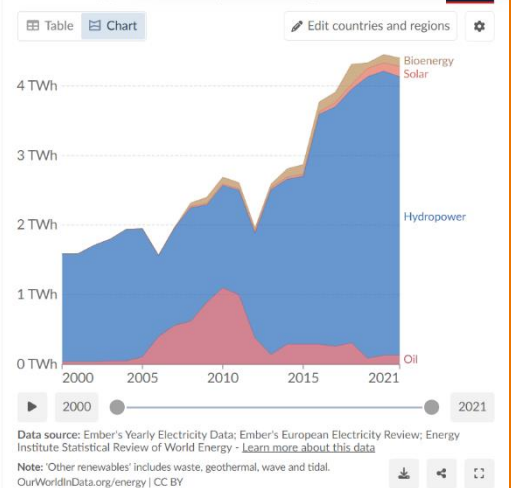
supply is met using renewables, traditional biomass sources account for 99% of that, leading to deforestation, land degradation and air pollution. While hydropower plays a vital role in the country's electricity grid (84%), due to limited electricity infrastructure in large parts of the country, biomass remains the dominant energy source for everyday household activities. [3]

Total energy supply (TES) by source, Uganda 1990-2020



[11]

Electricity production by source, Uganda



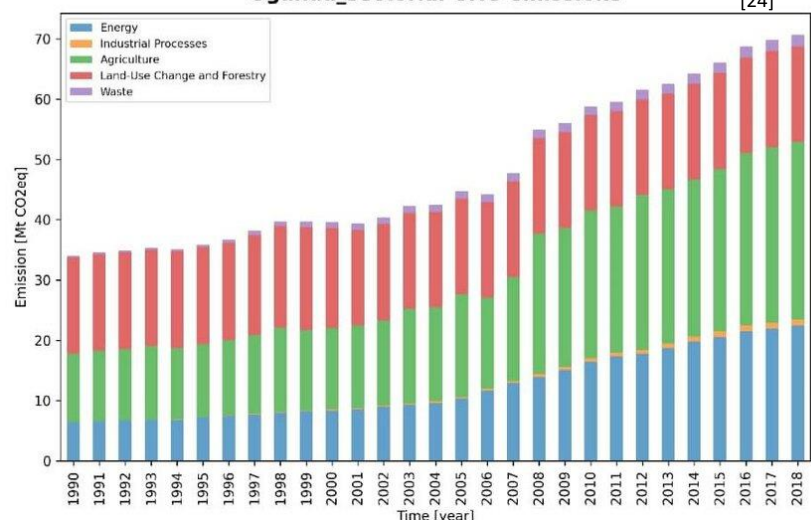
[12]

Greenhouse Gas Emissions

Uganda, with its predominantly agrarian economy, has relatively low greenhouse gas (GHG) emissions compared to many industrialized nations. Uganda's GHG emissions totaled approximately 39.28 million metric tons of CO₂ equivalent in 2020 [1]. The agricultural sector, responsible for around 80% of the country's emissions, emits methane (CH₄). Deforestation and land-use changes account for a substantial portion, with Uganda losing an estimated 90,000 hectares of forest annually, releasing substantial CO₂ emissions. Traditional biomass usage for cooking and heating, prevalent in 90% of households, as well as the increasing electricity generation also contribute significantly to emissions.

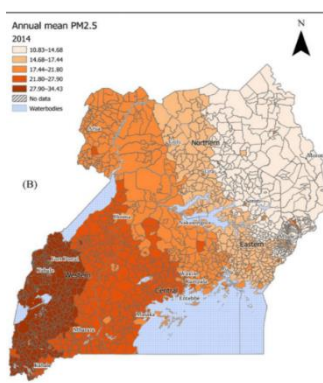
Uganda_sectorial GHG emissions

[24]

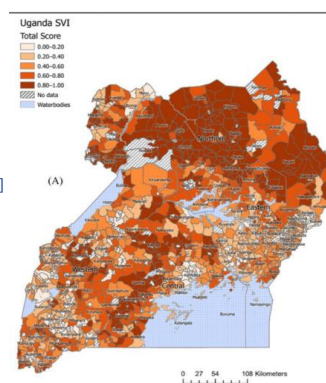


Pollution Status

Uganda faces significant environmental challenges. The 2022 Average US AQI for Uganda was 111, which is unhealthy for sensitive groups and the PM concentration was 2.5, 7.9 times the WHO annual air quality guideline value. About 20,000 Ugandans die annually due to air pollution-related illnesses. Water pollution affects approximately 2.4 million Ugandans, contributing to the spread of waterborne diseases. Improper waste management results in 1.3 million tons of solid waste generated annually in urban areas, worsening soil and water quality. Additionally, the country grapples with rising noise pollution due to rapid urbanization. Efforts to combat pollution include initiatives to reduce vehicular emissions, improve waste management, and promote clean energy solutions.



Particulate matter ^[15]



Social Vulnerability
Index to air
pollution ^[15]

FIGURE 2: DROUGHT RISK

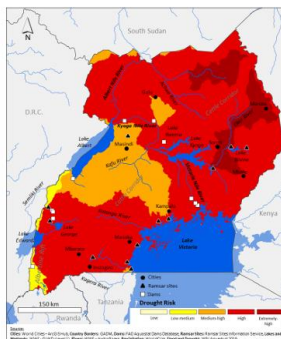
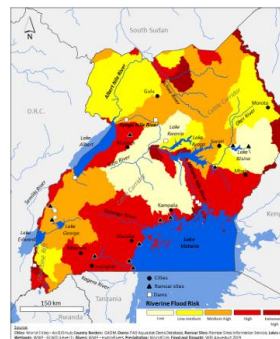
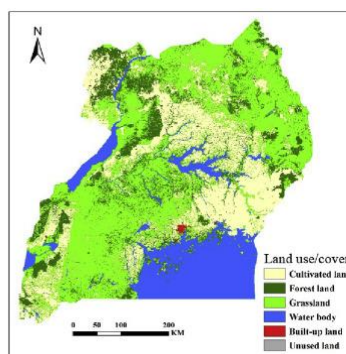
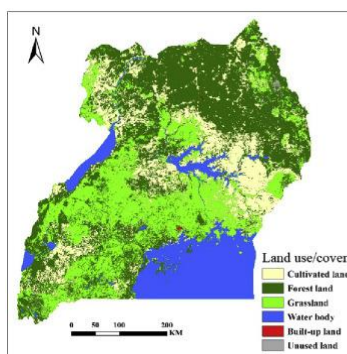


FIGURE 3: RIVERINE FLOOD RISK



Water pollution ^[16]



Deforestation ^[25]

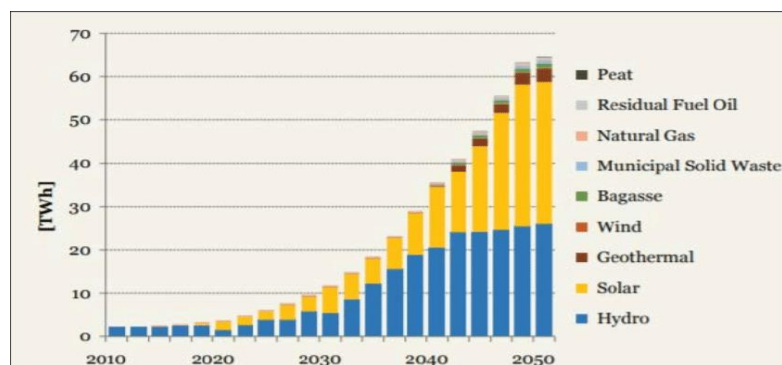
Global Commitments

Uganda is a party to international agreements aimed at reducing greenhouse gas emissions and mitigating climate change such as Paris Agreement, Sustainable Development Goals, African Union's Agenda 2063 and United Nations' SEforALL Initiative. The country is committed to fulfilling its obligations under these agreements, working towards a sustainable energy future, and collaborating with the international community to address global environmental challenges.

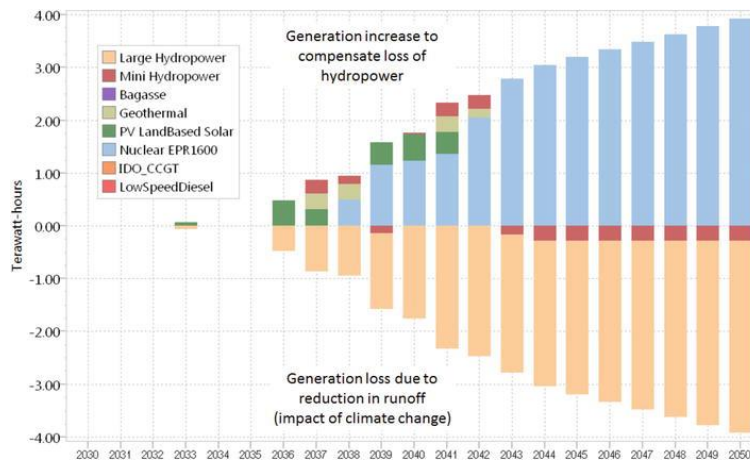


Progress in Renewable Energy Deployment

Uganda's renewable energy sector has seen significant growth, with a focus on hydropower, solar, biomass, and biogas. Major hydropower projects like Bujagali contribute significantly. Solar initiatives, both grid and off-grid, are expanding rapidly, especially in rural areas. Biomass and biogas utilization are prevalent, promoting sustainable energy practices. Uganda is also exploring wind and geothermal potential. Mini-grids powered by renewables are extending electricity access. Government support through incentives and favorable policies has spurred private investment, making Uganda a regional leader in clean energy adoption.



[20]



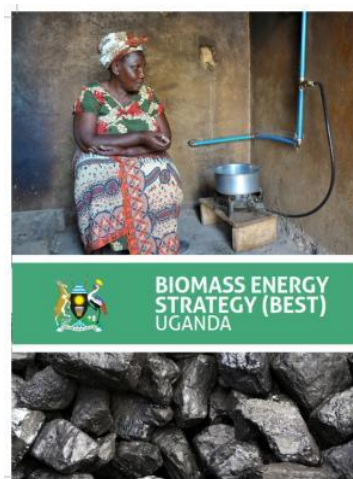
[19]

Policy Measures

Uganda has implemented various policy measures to improve energy efficiency, harness renewable sources of energy, and mitigate carbon emissions:

1. Rural Electrification Strategy
2. Renewable Energy Feed-in Tariffs
3. Energy Efficiency Initiatives
4. National Development Plan
5. Off-Grid Renewable Energy
6. Climate Change Policy
7. Private Sector Engagement
8. National Biomass Energy Strategy

These policy measures reflect Uganda's commitment to sustainable energy practices, fostering economic growth, energy security, and environmental conservation.



Conclusion and Recommendations

In conclusion, Uganda's energy sector is at a pivotal juncture, balancing the demands of economic growth, environmental sustainability, and social well-being. Uganda's rich blend of fossil fuel reserves and diverse renewable sources positions the country favorably for energy security and sustainability, however the latency in their harnessing and development of suitable infrastructure gravely hamper the energy security of the country. Nevertheless, the country has made commendable strides in diversifying its energy mix, emphasizing renewable sources, and enhancing energy accessibility. Some recommendations to further improve accelerate the process are as follows:

1. Investment in Research and Development
2. Grid Infrastructure Enhancement
3. Rural Electrification Acceleration
4. Promotion of Energy Efficiency
5. Public Awareness and Education
6. Private Sector Partnerships
7. Policy Framework Strengthening

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