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ELECTRICITY REGULATORY AUTHORITY

THE ELECTRICITY SUPPLY INDUSTRY STATE OF THE ENVIRONMENT

REPORT 2023

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The Electricity Supply Industry State of the Environment Report 2023



Front page photo:
Achwa 1 Hydropower Project with powerhouse, tailrace, switchyard, and transmission line. The weir, intake and upper part of the headrace canal for Achwa 2 Hydropower Project visible in the background (photo by Arpe Limited).

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Foreword



As the Chairperson of the Board of the Electricity Regulatory Authority (ERA), I am pleased to brief our stakeholders about this first-ever Electricity Supply Industry State of the Environment Report (ESISOER) in Uganda.

The Electricity Regulatory Authority is a statutory body established under Section 3 of the Electricity Act, Chapter 157 Laws of Uganda ('Act'), to regulate the generation, transmission, distribution, sale, export, and import of electrical energy in Uganda, among other functions listed in Section 9.

Thus, the Act vested in ERA the responsibility to oversee all activities in Uganda's Electricity Supply Industry (ESI).

Therefore, under the National Environment Act, 2019 (NEA), ERA is obliged to discharge the functions of a lead agency; as listed in Section 11, including the preparation of the state of environment report for the Electricity Supply Industry in accordance with Section 46.

In fulfilment of the NEA requirement, ERA has prepared its first ever ESISOER 2023. This being the first ESISOER, it covers most of the significant environmental and social issues associated with the Electricity Supply Industry (ESI) activities and development. The report is intentionally kept at a general level in order to form a baseline for future ESISOERs. The subsequent ESISOERs shall be more specific (focused) on environmental issues and challenges occurring in the reporting period (past two years).

It is important to note that an ESISOER is a high-level tool used to monitor and assess changes in the environment and provide information necessary to put in place measures and/ or "best practices" to manage the environment.

Using the Driver-Pressure-State-Impact-Response (DPSIR) analytical model, we provide in the report a description of the changes in the environment resources used in the ESI activities and information necessary to put in place measures and/ or "best practices" to manage these resources. The six thematic areas described are as follows;

i. Water Resources
ii. Biodiversity
iii. Social Environment
iv. Health and Safety
v. Waste and Pollution
vi. Climate Change Mitigation and Adaptation

For each of the thematic areas, the report has made recommendations for action by the mandated ministry, department or agency (MDA) and stakeholders, including ERA licensees. It is envisaged that these actions will be mainstreamed into institutional plans of the relevant MDA, stakeholders, licensees and development partners, to intervene and/ or support efforts to address the identified environmental and social concerns in Uganda's ESI. I encourage all public and private institutions to embrace and make use of this report.

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As I conclude, I wish to emphasise that in the discharge of the Authority's mandate under the Electricity Act, ERA's goal is to guarantee the public their Constitutional right to a clean and healthy environment, and also ensure the needs of the future generation and are not compromised.

I take this opportunity to sincerely thank the Hon. Minister of Energy and Mineral Development – Hon. Dr. Ruth Nankabirwa Ssentamu, for her guidance and support in the execution of the ERA mandate. In a special way, I thank the ERA Board Members namely; Eng. Joseph Oteng Otogo, Ambassador Joan Rwabyomere, Professor John Ddumba-Ssentamu, and Eng. Eriasi Kiyemba for the support in regulating the ESI and good working relationship. I also extend my sincere appreciation to the Chief Executive Officer Eng. Ziria Tibalwa Waako and the entire ERA staff for their hard work and for realising the first ever, Electricity Supply Industry State of the Environment Report (ESISOER) in Uganda.

Dr. Sarah Wasagali Kanaabi

CHAIRPERSON: BOARD OF THE ELECTRICITY REGULATORY AUTHORITY

Acknowledgment



First and foremost, I take this opportunity to extend my sincere gratitude to the Royal Norwegian Embassy in Kampala together with the Norwegian Water Resources and Energy Directorate (NVE) for the financial and technical support to the Electricity Regulatory Authority (ERA) that has enabled us to pull off this first ever, Electricity Supply Industry State of the Environment Report (ESISOER) in Uganda.

In the same vein, I thank all the technical team of experts from NVE and Multiconsult that contributed immensely to the compilation of this report,

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and in particular, Arne Trond Hamarsland and Svein Erik Hårklau respectively. Thank you so much.

In a special way, I thank Gunn Oland and Michael Steinfeld for their leadership and for successfully coordinating the NVE-ERA Technical Assistance Programme, which supported the production of this report.

I extend special gratitude to my technical teams led by ENG. Judith Nayiga and Dr. Geofrey Okoboi, that initiated and authored this great piece of work namely; Peter Kityo, Andrew Aloka, Yayiru Tibara, Milly Nakimuli, and James Mukwaya, including the Coordinator of the NVE programme, Isaac Kinhonhi. Thank you very much for delivering this milestone and for helping ERA account to the public on how environmental resources are utilized and managed in the ESI.

I thank the National Environment Management Authority (NEMA), for the technical guidance and support during the compilation of this first ever ESISOER. I am indeed proud of the cordial working relationship between the NEMA and the ERA.

I am also indebted to all Government and private institutions that provided spatial information (GIS data) that made the analyses and compilation of this report much easier namely; National Forestry Authority, the Ministry of Works and Transport, Ministry of Energy and Mineral Development, Uganda Electricity Transmission Company Limited, Uganda Electricity Distribution Company Limited, Umeme Limited and Geotropic Consults Ltd. Thank you so much for the technical input and support.

I am also grateful to all institutions listed in Annex 1 that participated in the stakeholder workshop to review and validate the draft ESISOER, for their constructive comments and input, which positively shaped the quality and narrative of this report.

To all the ERA staff and Management, I thank you for the support and contribution you made in one way or the other during the compilation of this report, including the reviews and comments. I appreciate and I am proud of the teamwork and team spirit exhibited in the compilation of this report, and also in the execution of the ERA mandate. Thank you, Team ERA!

To the ERA Board, thank you so much for steering and guiding the technical team headed by myself, to deliver this piece of work and thus fulfilling your lead agency role under the National Environment Act, 2019. I thank the Chairperson and her Board Members for caring for the environment, and for ensuring that the ESI is accountable to the public on matters of protection of the environment.

Last but not least, I thank the Ministry of Energy and Mineral Development for the policy guidance and support in regulating the ESI.

Eng. Ziria Tibalwa Waako

CHIEF EXECUTIVE OFFICER

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EXECUTIVE SUMMARY

Introduction

This document is the first State of the Environment Report for the Electricity Supply Industry in Uganda, prepared as per the requirements under Section 11(d) and Section 46(3) of the National Environment Act, 2019. This Report has been prepared by the Electricity Regulatory Authority (ERA) with support from the Norwegian Water Resources and Energy Directorate (NVE) through funding from the Royal Norwegian Embassy in Uganda.

The Electricity Supply Industry and the Environment

The provision of electricity is essential for the national economy and for the welfare of many Ugandans. Electricity currently represents approximately 2% of the energy use in Uganda with biomass still dominating (87%) the overall energy use and fossil fuel products contributing 11%. Electricity consumption is expected to increase from 215 kWh per capita in 2022 to 3,668 kWh per capita by 2040 due to an increase in existing demand areas and emerging uses of electricity.

The electricity demand is the underlying driver of changes in the state of the environment and the impacts associated with electricity generation, transmission and distribution in the Electricity Supply Industry. Understanding and adequately managing the environmental, social, health and safety (ESHS) risks and opportunities associated with the growing Electricity Supply Industry is important for the environment, for the people depending on natural resources affected by the Electricity Supply Industry, and for the long-term sustainability of the economy.

There are several important linkages between the Electricity Supply Industry and the environment identified in this Report. The main sources of electricity in Uganda are environmental resources, particularly water and biomass but also solar radiation and fossil fuels. Land is not a source of electricity but provides the base on which the electricity infrastructure

is supported and operated because the electricity generation plants and transmission and distribution lines require land.

Acquisition and use of these environmental resources may lead to negative consequences such as displacement of people, loss of people's property, limit their access to natural resources or affect ecosystems health of forests, wetlands, or rivers, which many people depend on for their day-to-day livelihood. Construction activities and plant operations may also result into pollution of water, land, air, or noise.

On the other hand, exploitation of environmental resources for electricity production, also presents opportunities and benefits. For example, changing from use of heavy fuel oil, diesel or kerosene to electricity generated from renewable sources like hydropower, solar PV or biomass may reduce air pollution, including greenhouse gas emissions, and the associated health risks.

The above and other linkages between the Electricity Supply Industry and the environment are explored in this Report.

Purpose and Objectives

The main objective of the Electricity Supply Industry State of the Environment Report (ESISOER) is to inform the Electricity Supply Industry stakeholders and the public about the Electricity Supply Industry's impacts on the environment, their control measures, the changes or trends in the environmental resource conditions, and how environmental impacts may be managed in future Electricity Supply Industry development, for sustainability. Specific objectives of the Report include:

1) Fulfil the legal requirement under the National Environment Act, 2019, and contribute to Uganda's fulfilment of its obligations under international environmental conventions such as the Earth Summit (Agenda 21) where each signatory country is obliged to prepare a regular State of the Environment Report.
2) Describe the status and trends in the Electricity Supply Industry and the environmental resources affected by the sector.

3) Describe baseline information on environmental resources and Electricity Supply Industry activities and their impacts on the resources, for future monitoring of environmental performance in the Electricity Supply Industry.
4) Highlight environmental performance, challenges, and opportunities in the sector.
5) Identify environmental risks and/ or impacts not previously known in the Electricity Supply Industry so that these can be understood and managed.
6) Make recommendations for improvements in environmental management in the Electricity Supply Industry, including in infrastructure planning, design, development, operation, and maintenance.
7) Make recommendations for improvements in policies, responses and future frameworks and initiatives.

Electricity Supply Industry

Generation

Hydropower currently represents the backbone of Uganda's electricity generation with approximately 82% (1,510 MW) of the total licensed, commissioned capacity of 1,847.5 MW and generated 93% of the electricity supplied to the national grid in 2023. More than 35 hydropower projects are operational ranging from micro hydropower plants to large hydropower plants. Thermal power plants using biomass (co-generation) represent the second largest licensed, commissioned capacity (8%) followed by thermal power based on fossil fuels (5.4%), and solar PV plants (4.5%). Electricity generation in 2023 was 3.9%, 1.6% and 1.1% from co-generation, solar PV, and fossil fuel plants, respectively. This means that almost 99% of electricity generation to the national grid in Uganda is from renewable energy sources. There is considerable potential to increase electricity generation from renewable sources, particularly hydropower and solar PV.

Transmission

More than 4,500 km of high-voltage transmission circuits (66 kV, 132 kV, and 220 kV) have been constructed to evacuate electricity from the generation sites to the main load centres where consumers are located. Substantial lengths of additional transmission lines will be developed to increase and improve power supply across the country as well as to connect the grid to neighbouring countries for export and import.

Distribution

A comprehensive network of approximately 65,000 km of medium and low-voltage distribution lines (33 kV, 11 kV and low voltage) has been constructed. Increasing electricity access will involve the construction of many new distribution lines across the country. A total of 6,000 km of low voltage (2,900 km) and medium voltage (3,100 km) lines will be added under the World Bank funded Electricity Access Scale-up Project, over the next five-year period, up to June 2027. An estimated 1,223,500 households, commercial enterprises, industrial parks, and public institutions will be connected under this project.

Access to Electricity

The proportion of the population with access to electricity from the national grid has been growing and reached 28% while 57% of households have access to at least one source of electricity according to the Energy Policy 2023. The national objective to ensure electricity access for all, whether from the national grid or off-grid solutions, will require large investments to expand generation, transmission, and distribution.

ERA's Regulatory Roles

The Electricity Regulatory Authority (ERA) is a statutory body established under the Electricity Act to regulate the generation, transmission, distribution, sale, export and import of electrical energy in Uganda. Among other things, ERA issues licences for generation, transmission, distribution, and sale of electricity.

The Electricity Act gives ERA the mandate to control all the activities in the Electricity Supply Industry, thus under the National Environment Act, 2019, ERA is considered a lead agency, and thus responsible for the discharge of roles under Section 11 of the National Environment Act. These include; to plan, regulate and manage the segment of the environment within ERA's mandate; carry out strategic environmental assessments; prepare an environment action plan; prepare the state of environment report; undertake environmental inspections and review environment assessments and environmental audits; ensure that any activity undertaken in ERA's area of jurisdiction is in compliance with the law; report on progress quarterly and account to the National Environment Management Authority (NEMA) for the execution of its role in relation to environmental management within three months after the end of the financial year; and implement and enforce the provisions of National Environment Act.

Environmental Issues in the Electricity Supply Industry

The environmental issues in the Electricity Supply Industry have been considered in this ESISOER using the same analytical framework used by NEMA in the preparation of the National State of the Environment Report for Uganda, that is, the Driver-Pressure-State-Impact-Response (DPSIR) Framework.

Some of the environmental issues and main changes in the state of the environment and impacts related to the Electricity Supply Industry are summarised below. Additional details and issues are included in the main text.

Water Resources

1) Water abstraction for hydropower results in reduced flow in certain river sections and therefore reduced water availability for water users and loss of habitat and associated population reduction of plants and animals.
2) Water pollution occurs during project construction activities, primarily from earthworks followed by soil erosion. Incidences of oil spills can happen during operation of the generation projects and

in substations during maintenance operations. Hydropower projects may discharge substantial volumes of sediments from the dam.

3) Storage of water in hydropower reservoirs can change the timing of river flow downstream of the reservoir by reducing flow in natural high flow periods (storing water in reservoir) and increasing flow in natural low flow periods (releasing water from reservoir).

4) Hydropeaking at hydropower projects can result in short-term, large variation in downstream flow due to large water releases for power generation during peak electricity demand and low water releases during periods of low electricity demand.

Biodiversity

1) Land taken for the electricity projects can affect protected areas' integrity and functioning as well as contribute to the fragmentation of habitats, loss of habitats and ultimately resulting in loss of biodiversity. Improved or new access roads to projects can increase harvesting of natural resources beyond sustainable limits.

2) Hydropower project dams and weir structures built across the rivers block and/or interfere with movement of fish migration and other aquatic life thus reducing their populations. Diversion of rivers for hydropower reduce biodiversity in affected river sections.

3) Loss of biodiversity reduces access to ecosystem services for local people.

Social Environment

1) Land taken for the projects often displaces households and businesses and therefore reduces people's access to land, natural resources, income opportunities and causes loss of property and crops. People also need to be resettled and their livelihoods restored.

2) Access to water is reduced where people rely on river sections affected by water abstraction for hydropower.

3) Social networks can be disrupted, cultural heritage lost, and gender-based violence and sexual harassment occurs, particularly during construction where a larger workforce is employed.

4) Electricity supply is the main positive impact for people, businesses and institutions connected to the grid.
5) Employment opportunities is another positive impact from Electricity Supply Industry development and operation activities and associated businesses.

Health and Safety

1) Certain power project activities present high-risk work conditions and project facilities, which have resulted in injuries and fatalities of workers and local people.
2) Noise and air pollution from the power projects result in health problems mainly for project workers and at times for surrounding local people.
3) Population influx, particularly during construction, can result in increased disease prevalence.
4) A positive impact is the replacement of biomass for cooking or kerosene for lighting with electricity, which reduces indoor air pollution and associated health problems.

Waste and Pollution

1) Thermal power plants emit gases and particles that result in local air pollution and greenhouse gas emissions.
2) Hazardous materials and hazardous waste are common at Electricity Supply Industry projects and can harm the environment and people unless appropriately transported, stored, used, and disposed.
3) Poor practices for releasing accumulated sediments from hydropower reservoirs have been resulted in serious river pollution to the detriment of domestic water supply and ecosystem functions, particularly the aquatic ecosystems, sometimes leading to fish death.
4) Replacing the use of fossil fuels with renewable energy reduces air pollution, including greenhouse gas emissions.

Climate Change

1) The Ugandan climate is increasingly unreliable. Hydropower, which is the electricity generation backbone in Uganda, is particularly vulnerable to changes in rainfall patterns, both due to drought and flood risks.
2) The proportion of power generation based on fossil fuels have reduced substantially since 2012, when the 250MW Bujagali hydropower plant was commissioned. Additional hydropower projects have since resulted in more than 90% of the electricity being generated from hydropower and 98% from renewable energy sources (hydropower, biomass co-generation, and solar PV). There is potential for further growth in renewable electricity generation, including addition of geothermal and wind to the generation mix.
3) Adaptation and strengthening the resilience of electrical installations and systems to climate change are still in their infancy in Uganda's Electricity Supply Industry.

Policy Responses and Recommendations

Some of the main current responses and recommendation for improved environmental management in the Electricity Supply Industry are summarised below. Additional responses and recommendations are included in the main text. ERA has initiated collaboration with other lead agencies to manage environmental issues and will continue to strengthen existing as well as establish new collaborations.

Water Resources

1) Environmental Flow: Environmental flow (e-flow) releases are being promoted at all hydropower projects. It is recommended that the e-flow releases must ensure sufficient water for ecosystems and water users in the affected river section and that guidelines for e-flow are developed by DWRM in collaboration with ERA and NEMA.
2) Water pollution: Mitigation measures to avoid and minimise water pollution are implemented in Electricity Supply Industry projects. It is recommended that DWRM, in collaboration with ERA and NEMA,

develop more specific requirements and supporting guidance to control pollution and that these are accompanied by more robust water quality monitoring by both the water authorities and the project owners. More specific procedures should cover, among others, methodologies for earthworks, procedures for sediment flushing at hydropower projects, and oil/water separators.

Biodiversity

1) High-value Areas: Impacts on protected areas, natural forests, and important habitats are avoided in many, but not all, Electricity Supply Industry projects. It is recommended to supplement existing project-by-project assessments with more holistic assessments of cumulative impacts from multiple projects within and outside the sector to minimise the current loss and fragmentation of important habitats due to insufficient assessment of cumulative impacts.
2) Cumulative Impacts: The Victoria Nile system starting in Jinja represent the backbone for electricity generation in Uganda and is the most affected river system by hydropower. It is recommended that MEMD, in collaboration with MWE, NEMA, UWA, DWRM and ERA, undertake a cumulative environmental and social impact assessment to guide a balanced development and operation of the hydropower resources on this river system while also taking other societal interests into account.
3) Fish migration: A small number of hydropower projects implement fish passage solutions but often there is insufficient knowledge of fish migration in rivers. It is recommended that NEMA, in collaboration with ERA and fisheries authorities, undertake studies of rivers likely subject to future or further hydropower development to understand the potential presence of existing barriers (natural or man-made) to upstream fish migration as well as the presence of migratory fish species.

Social Environment

1) Land taken: Projects avoid and minimise land take to reduce project costs for compensation and to reduce adverse impacts on people, but projects cannot fully avoid taking land. Increases in the projects' land taken after approval are often observed. These need

to be avoided and/or minimised through improved project planning, and where these increases or changes are unavoidable, improved management of local concerns is recommended.

2) Water Supply: Water abstraction for hydropower is in some projects mitigated by project developers who provide water supply schemes with improved access to water for affected people. It is recommended that people whose water supply is affected by the water abstraction for power generation should always benefit from measures to improve access to water.

3) Socio-economic Benefits: Measures to expand access to electricity in areas affected by Electricity Supply Industry projects can reduce project-related conflicts and strengthen local development and support to the Electricity Supply Industry. Other community projects prioritised by affected communities are also recommended to be supported by project owners.

Health and Safety

1) High-risk Contexts: High-risk work conditions and project facilities are subject to many requirements that project owners and contractors implement. Nevertheless, several of the high-risk conditions (e.g., work at height, work in rivers, and increase in disease prevalence) and facilities (e.g., energised electricity installations) require improved preventive measures by owners and contractors and strengthened monitoring also by lead agencies to avoid and minimise fatalities and serious injuries.

2) Dam Safety: Dam safety and waterway guidelines and regulations are being developed by relevant agencies. It is recommended that the different waterways and dams (e.g., open headrace canals, high-pressure penstocks, and large dams) be classified in terms of risk to inform the development and implementation of appropriate measures, including emergency preparedness and response plans for each installation.

3) Indoor Air Pollution: Health problems from indoor air pollution associated with cooking and lighting should be further reduced by expanding electricity access to replace solid biomass as cooking fuel and kerosene for lighting.

Waste and Pollution

1) Greenhouse Gas Emissions: Renewable energy resources currently dominate electricity generation and the reliance on fossil fuels has been dramatically reduced since 2012. To minimise local air pollution and greenhouse gas emissions, it is recommended that renewable energy is further scaled up to minimise reliance on fossil fuels.
2) Waste Management: Electricity Supply Industry projects implement several waste management measures to meet regulatory requirements. More specific requirements are nevertheless recommended for handling of hazardous materials and hazardous waste (e.g., storage facilities, and oil/water separators) to reduce risks of pollution from poorly designed or operated waste containment facilities.
3) Sediment Flushing: It is recommended that NEMA, in collaboration with ERA and DWRM, develop more specific requirements for sediment management, and sediment flushing in particular, at hydropower projects to minimise risks of highly detrimental downstream impacts during sediment flushing.
4) PCBs: Strengthened efforts by ERA, in collaboration with NEMA and licensees, are recommended to eliminate polychlorinated biphenyls (PCBs) for electrical installations and equipment (e.g., transformers) in line with Uganda's obligations under the Stockholm Convention on Persistent Organic Pollutants and the National Environment Act.
5) Sulphur Hexafluoride: Strengthened efforts by ERA, in collaboration with NEMA and licensees, are recommended to avoid and minimise leakages and emissions of the extremely potent greenhouse gas sulphur hexafluoride (SF_6) from electrical installations.

Climate Change

1) Vulnerability: The Electricity Supply Industry's reliance on hydropower is an effective mitigation against greenhouse gas emissions but also leaves the ESI vulnerability to climate change due to the reliance on water resources. An assessment of the sector's vulnerability is recommended as basis for strengthened adaptation

and resilience at sector and project levels in a more climate-unstable future.

2) Renewables: Increased generation from renewable energy sources is recommended as a main strategy to maintain low greenhouse gas emissions from electricity generation. Increased generation should be based on concurrent diversification of renewable energy sources such as solar, biomass, wind and geothermal combined with energy storage.

Cross-cutting Issues

1) SOER Guidelines: This ESISOER, which is the first sectoral SOER in Uganda, was prepared without clear guidelines for sectoral SOERs. It is recommended that NEMA develops guidelines for sectoral state of the environment reports for future guidance.
2) Monitoring and Reporting: The preparation of the ESISOER has identified many gaps in available environmental data. It is recommended that monitoring and reporting across all relevant lead agencies be strengthened and that data be made available for interested stakeholders. Collaboration between agencies requires strengthening.
3) Capacity Enhancement: For priority areas identified in this report, it is recommended that capacity enhancement is undertaken for ERA and other relevant agencies to support improved data collection and analysis.

Monitoring Recommendations

Based on the assessments undertaken for this ESISOER, several recommendations for improved monitoring were identified and are summarised below.

Water Resources

1) Environmental Flows: Improved monitoring and reporting of hydropower developers' environmental flow releases by the Ministry responsible for water resources and the effectiveness of these releases in terms of mitigating adverse environmental and social impacts from water diversion.
2) Water Quality: Improved water quality monitoring and reporting by the Ministry responsible for water resources with priority on water quality characteristics that relate to the Electricity Supply Industry projects, including hydropower and co-generation projects.

Biodiversity

1) Habitat Loss: Improved monitoring and reporting of loss and fragmentation of important habitats, including cumulative impacts from Electricity Supply Industry projects.
2) Fish Migration: Improved monitoring and reporting of fish migration patterns in selected river systems important for hydropower development.

Social Environment

1) Land Taken: Improved monitoring and reporting of land taken by Electricity Supply Industry projects from the start of construction to commissioning, including monitoring of the management of changes in land take, compensation, livelihood restoration and local grievances.
2) Access to Water: Improved monitoring and reporting of quantity and quality of water available to people affected by water abstraction for hydropower.
3) Electricity Access: Improved monitoring and reporting of electricity access in communities affected by Electricity Supply Industry

projects, including the extent to which projects increase local connections and quality of electricity delivery by licensees.

Health and Safety

1) Monitoring and Reporting: Improved monitoring of fatalities, serious incidents, and emergencies, including documentation of root causes of such incidents, as well as improved reporting of such incidents to relevant authorities by licensees/project developers.

Waste and Pollution

1) Sediment Flushing: Monitoring and reporting of sediment flushing and associated impacts on local people, water users and the river ecosystem by hydropower project developers/licensees.
2) PCBs: Monitoring and reporting of the presence of PCBs at electrical installations by licensees.

Climate Change

1) Adaptation: Monitoring and reporting of implementation of climate change adaptation and resilience measures and their effectiveness by licensees/developers.

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Annex 3: Supplementary Data on Electricity Supply Industry Projects

Unclassified

INTRODUCTION



The 132 kV Muzizi Substation under construction in Kagadi District (photo by ERA).

Unclassified

INTRODUCTION



The 132 kV Muzizi Substation under construction in Kagadi District (photo by ERA).

1 INTRODUCTION

1.1 Background

Electricity is a key driver of the socio-economic transformation of a nation. For Uganda to shift from a lower-middle-income to an industrialized and largely urban society, it must be propelled by electricity as a form of modern energy. Electricity raises the standard of living of citizens of any country, as is evident from the correlation between per capita electricity (a proxy for all energy forms) consumption and the Human Development Index (HDI).

Uganda remains energy-poor, with low levels of electricity and clean cooking access, and among countries with the lowest levels of modern energy consumption per capita globally. Around 90.5% of Uganda's energy needs are still met by solid bioenergy, given it is the only energy source available to many in rural areas (IEA, 2023; MEMD, 2023). The Uganda Vision 2040 indicates that to achieve the targets of this vision, Uganda will develop and generate modern energy to drive the industry and services sector. The 2023 Energy Policy estimated that Uganda will require approximately 52,000 MW by 2040 thus increasing its electricity consumption per capita from 215 kWh in 2022 to 3,668 kWh in 2040 (MEMD, 2023: 16). Furthermore, the access to the national grid must significantly increase to 80%.

The average demand growth under the base case scenario is 8.5% per year as of 2023 while the high case demand scenario is 12.2% per year (ERA, 2021). The total average demand is projected to increase from 936 MW to 3,662 MW for the base case from 2023 to 2040, and the total available generation from 1,823 MW to above 2,500 MW in the same period. The demand-supply balance is projected to have a supply shortfall of more than 1,100 MW by 2040 in the base case and by more than 5,100 MW in the high-case demand forecast scenario in 2040. Access to power is at 57% of which 19% is on-grid and 38% off-grid. Uganda's per capita consumption stood at 215 kWh as of 2022 (MEMD, 2023).

The 2030 United Nations Sustainable Development Goals (SDGs) provide the need for increased access to affordable and clean energy (goal 7); take urgent action to combat climate change and its impacts (goal 13); and to protect, restore and promote sustainable use of ecosystems (goal 15). These goals summarise key challenges for Uganda's Electricity Supply Industry.

The electric power systems consist of generation plants of different energy sources, transmission networks, and distribution lines. Each of these components can, however, have environmental impacts at multiple stages of their development and use including in their construction, during the generation of electricity, and in their decommissioning and disposal. Unless environmental issues are well understood and managed wisely, there can be adverse impacts on the environment that may have important side effects on the Uganda natural resources-based economy.

This report has been prepared in line with Sections 11 and 46 of the National Environment Act, 2019. One of the functions of the Electricity Regulatory Authority being a lead agency in the Electricity Supply Industry is to prepare the state of the environment report in accordance with Section 46 of the National Environment Act, 2019 (Section 11(d)), and the lead agency report is taken into consideration in the national state the of environment report as provided for under Section 46(2)(c). Further, under Section 10(m) of the Electricity Act, one of the functions of the Electricity Regulatory Authority is to prepare industry reports and to gather information from generation, transmission, and distribution companies. This Electricity Supply Industry State of the Environment Report (ESISOER) is expected to be updated every two years.

This ESISOER has been developed by a working group of representatives from ERA and NVE supported by consultants.

1.2 Objectives of the Report

The state of the environment reporting is a tool used to monitor and assess changes in the environment and provide information necessary to put in place sound measures to manage the environment.

The main objective of the ESISOER is to inform the Electricity Supply Industry stakeholders and the public about the Electricity Supply Industry's impacts on the environment, their control measures, the changes or trends in the environmental resource conditions, and how environmental impacts may be managed in future Electricity Supply Industry development, for sustainability.

Specifically, the report inter alia will:

1) Fulfil the legal requirement under the National Environment Act, 2019, and contribute to Uganda's fulfilment of its obligations under international environmental conventions such as the Earth Summit (Agenda 21) where each signatory country is obliged to prepare a regular State of the Environment Report.
2) Describe the status and trends in the Electricity Supply Industry and the environmental resources affected by the sector.
3) Describe baseline information on environmental resources and Electricity Supply Industry activities and their impacts on the resources, for future monitoring of environmental performance in the Electricity Supply Industry.
4) Highlight environmental performance, challenges, and opportunities in the sector.
5) Identify environmental risks and/ or impacts not previously known in the Electricity Supply Industry so that these can be understood and managed.
6) Make recommendations for improvements in environmental management in the Electricity Supply Industry, including in infrastructure planning, design, development, operation, and maintenance.
7) Make recommendations for improvements in policies, responses and future frameworks and initiatives.

1.3 Materials and Methods

1.3.1 Environmental Data

Information and data on environmental, social, health, and safety (ESHS) issues have been collected from several sources, including:

- Publicly available information nationally and internationally such as online databases (e.g., IBAT, WDPA), and web pages of relevant agencies (e.g., NEMA, UWA, Department of Occupational Safety and Health of the Ministry of Gender, Labour and Social Development).
- ESHS data available to ERA from the licensing processes (e.g., ESIAs, RAPs, permits from other agencies), site inspections (e.g., field observations), and reporting by licensees to ERA (e.g., Quarterly Reports to ERA).
- Other ESHS data was collected by the ESISOER Working Group.

ESHS data used in the GIS analysis is listed in Section 1.3.3 below.

1.3.2 Electricity Supply Industry Data

Information and data on the Electricity Supply Industry have largely been provided by ERA. This includes information about regulations and institutions in the Electricity Supply Industry and specific information about existing and planned infrastructure and projects in the electricity generation, transmission and distribution segments.

Data concerning projections and policy targets are mainly from the Energy Policy for Uganda 2023 by the Ministry of Energy and Mineral Development and strategic business plans of various institutions consulted.

1.3.3 Spatial Data

The analysis and presentation of information in this report are partly based on the use of geographic information systems (GIS). Spatial data

was required for the use of GIS, and the ERA engaged with key agencies to provide spatial data for the GIS analysis, including:

- Ministry of Energy and Mineral Development (MEMD)
- Ministry of Works and Transport (MoWT)
- National Forest Authority (NFA)
- Uganda Electricity Distribution Company Limited (UEDCL)
- Uganda Electricity Transmission Company Limited (UETCL)
- Umeme Limited

Information and data for specific Electricity Supply Industry projects have also been collected or digitised by the ESISOER Working Group. A small team of external GIS experts supported the Working Group in the GIS-related work. Annex 2 lists the sources of the main data used in the GIS analysis, including online sources used.

The datasets received were reviewed, various errors were corrected (e.g., coordinates/locations), and missing attributes were added jointly by ERA and the GIS experts (e.g., commissioning dates for project, development status of projects). The corrections and additions were based on documentation available to ERA, site visits undertaken by ERA as well as cross-checking against Google Earth/satellite image.

1.3.4 Analysis of Electricity Supply Industry – Environment Interactions

The National State of the Environment Report published by NEMA applies the Driver-Pressure-State-Impact-Response (DPSIR) framework when examining environmental thematic areas (see e.g., NEMA, 2017). This analytical framework is used to identify and understand linkages between human activities and the environment.

The framework identifies underlying drivers (D), that are typically underlying socio-economic needs or forces that result into pressures (P). The pressures, which are typically direct forces on the environment such as land take, resource extraction or pollutant releases, result into changes to the environment and thus the resultant environmental conditions give rise to a state (S). These changes in environmental

conditions are either positive or negative in nature and result impacts (I) on the environment, people or businesses that rely on the environmental resources or are otherwise affected by the environment, for instance in terms of risks for natural disasters.

This understanding of linkages between human activities and the environment, the cause-effect linkages, can be used to develop actions to address the impacts and/or issues arising from any of the previous steps in the cause-effect chain thus referred to as responses (R), see Figure 1-1 for illustration.

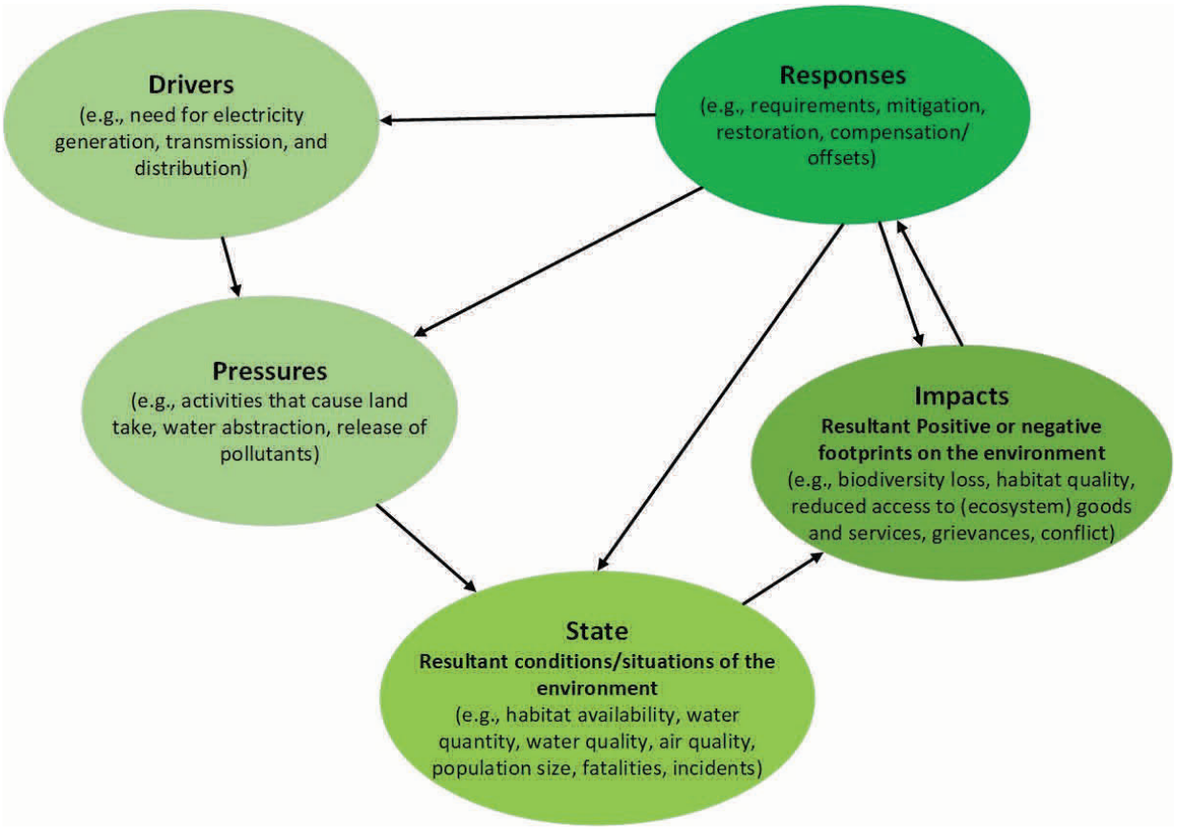


Figure 1-1: Illustration of the DIPSIR framework (Drivers-Pressures-State-Impacts-Response).

This ESISOER, which is the first Electricity Supply Industry State of the Environment Report in Uganda, seeks to apply the Drivers-Pressures-State-Impacts-Responses (DPSIR) framework where available data allows for this. The intention of the Electricity Regulatory Authority (ERA) is to expand the use of the analytical framework in future updates of the ESISOER as more data becomes available and methods are refined.

In this first version of the ESISOER, several indicators have been identified that were examined over time to detect trends and to identify key issues that may require responses in the form of corrective measures, intensified monitoring, regulatory action, or policy recommendations.
The scarcity of data and varying data quality meant that in only a few instances was it possible to compare data over time and detect well-documented trends. Future updates of this report will allow for further tracking of indicators, trends, and emerging issues as well as the effectiveness of responses that have been implemented based on monitoring data.

GIS analyses were used to estimate the size of areas affected by different Electricity Supply Industry projects (generation, transmission, and distribution), including different land uses and protected areas affected. For the high voltage transmission lines these analyses were using the wayleave distances in Table 1-3 below combined with the distances of the lines. Maps were generated using the QGIS software version 3.34.7.

1.3.5 Categorisations and Definitions

Within the Electricity Supply Industry, several terms are used to describe briefly types and sizes of projects, infrastructure or installation along the generation, transmission and distribution value chain and associated characteristics. For example, generation projects are typically divided into size categories as shown in Table 1-1 based on their installed generation capacity.

Table 1-1: Size categories for generation projects based on installed capacity.

Category	Installed capacity
Large	Above 100 MW
Medium	20-100 MW
Small	1-20 MW
Mini	0.1-1 MW
Micro	Less than 0.1 MW

For hydropower, this categorisation should not be confused with the International Commission on Large Dams (ICOLD) classification of "large dams", which is independent of the size of the installed generation capacity and also applies to dams not related to hydropower. A large dam is defined by ICOLD as a dam with a height of 15 metres or greater from the lowest foundation to the crest or a dam between 5 metres and 15 metres high and impounding more than 3 million cubic metres.

Power lines forming the electricity network are categorised according to the voltage level (see Table 1-2). Different voltages are associated with different levels of risks. Therefore, different sizes of zones are defined for the different categories of voltage level where certain activities are not accepted and restrictions along the power lines apply (see Table 1-3). It is important to note that a given wayleave (clearance/zone) has different implications for environmental and social issues. For example, the wayleave prohibits certain human activities within the wayleave but there are no social impacts outside the wayleave. In terms of environmental impacts, the impacts may go beyond the wayleave. For instance, bird species or wildlife losing their forest habitat due to cutting the trees in the wayleave may avoid areas also beyond the wayleave cut through a forest due to the fragmentation of a previously continuous habitat or due to changes in light conditions or microclimate in forest areas neighbouring the wayleave.

Table 1-2: Power line categories based on voltage.

Category	Voltage levels
Transmission	66 kV, 132 kV, 220 kV, 400 kV (high voltage)
Distribution	11 kV, 33 kV (medium voltage)
	Below 415 V (low voltage)

Table 1-3: Wayleave for different power line voltages.

Voltage level	Wayleave (on each side of the centre line)
400 kV	30 m + 30 m
220 kV	20 m + 20 m
132 kV	15 m + 15 m
66 kV	7.5 m + 7.5 m
33 kV and below	Land is not acquired but consent is sought prior to installation. Any damage to property/crops should be compensated.

Source: Modified from UETCL, undated.

1.3.6 Limitations

The preparation of this ESISOER had the following limitations:

1) At the time of preparation of this ESISOER, there were no guidelines for the preparation of the sector state of environment reports in line with Section 46(6) of the National Environment Act, 2019. In the absence of such guidelines, the ERA team applied the same main analytical framework as the National State of the Environment Report, namely the driver-pressure-state-impact-response (DPSIR) framework.
2) There was limited quantity and quality of data to support trend analyses for different environmental variables in the Electricity Supply Industry. For instance, water quality monitoring data were often associated with insufficient methodology descriptions or not possible to relate to specific activities, land take associated with power lines was not clear, biodiversity data were generally limited and not related to Electricity Supply Industry projects. Rarely were data available from before project implementation (baseline) and after implementation to enable tracking of trends and changes in the state of the environment. Some institutions did not provide or are not in possession of the data required for analysis. The ESISOER Working Group has compiled some new datasets on river fragmentation, water diversion along river sections, and

resettlement of people, but additional data will need to be collected for future versions of the ESISOER.

3) The GIS datasets had gaps, inconsistencies and missing information on attributes. Some, but not all, were corrected or filled by the ESISOER team. Further efforts will be required to supplement the dataset and enable more comprehensive GIS analyses.

4) The experience on compilation of the State of the Environment Report in the Electricity Supply Industry is limited. Nevertheless, the first ESISOER provides a foundation to build on in future ESISOER versions.

5) Limitations on specific data on various variables also resulted in difficulties in attributing trends and impacts to the Electricity Supply Industry in situations where developments outside the Electricity Supply Industry in a project area potentially contributed to the observed cumulative impacts, for instance, road development, conversion of natural habitats to agriculture, housing developments, etc. Overcoming such data limitations will require strengthened interagency collaboration.

6) A large proportion of the Electricity Supply Industry infrastructure consists of medium and low-voltage power lines. Due to the long distances covered by such lines and the relative proximity between many of these lines, it is challenging to process data for these lines. Further, most of these lines are in relatively densely populated areas, where the state of the environment will be affected by many other human activities (roads, industries, housing, agriculture, etc.), some of which took place before the power lines were constructed. These activities make it practically impossible to meaningfully isolate environmental trends or impacts associated with the Electricity Supply Industry. This report has therefore focussed on high-voltage transmission lines rather than medium and low-voltage lines.

7) For this ESISOER, some electricity generation technologies have not been considered such as wind, peat, nuclear, and hydrogen. The focus has been on technologies that currently contribute power to the national grid, where more information is available.

1.4 Structure of the ESISOER

The main parts of this ESISOER following this introduction (Section 1) are structured by theme, namely:

- Section 2 provides an overview of the Electricity Supply Industry to contextualise the subsequent sections on different environmental and social areas.
- Section 3 provides a description of the underlying driver of environmental and social change in the sector as well as the main pressures arising from the driver. The potential results of these pressures are summarised for various thematic areas in the subsequent Sections 4 to 9.
- Section 4 covers water resources, Section 5 covers biodiversity, Section 6 deals with the social environment, Section 7 covers health and safety for both workers and local communities, Section 8 covers waste and pollution, while Section 9 describes climate change mitigation and adaptation in the Electricity Supply Industry.

In Sections 4 to 8, and partly in Section 9, the information is structured in line with the DPSIR framework. This means that after introducing the thematic area, the driver and pressures are outlined before describing the resulting state and impacts. Current responses by project developers and lead agencies to address the driver, pressures, state, and impacts are thereafter described. Each section ends with a set of recommendations, which may be concerned with policy, actions or implementation of measures. The recommendations typically build on or go beyond the current responses.

1.5 References

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Unclassified

ELECTRICITY SUPPLY INDUSTRY



The 20MW Nkonge Solar PV power project during construction in Mubende District (photo by ERA).

Unclassified

ELECTRICITY SUPPLY INDUSTRY



The 20MW Nkonge Solar PV power project during construction in Mubende District (photo by ERA).

2 ELECTRICITY SUPPLY INDUSTRY

This section provides an overview of the Electricity Supply Industry (ESI) in Uganda. The ESI encompasses the generation, transmission, distribution, and sale of electric power to the general public and industry.

In this Chapter, first, the historical context of the electricity sub-sector is outlined, including the first sector reforms, the mergers of Government of Uganda (GoU) companies in the ESI and the second sector reforms (future outlook). The policy, regulatory, and institutional frameworks of the ESI are also described in this chapter.

2.1 History of the Electricity Supply Industry in Uganda

2.1.1 Development of the ESI in Uganda

The development of Uganda's Electricity Supply Industry (ESI) dates back to 1905 when Sir Winston Churchill identified the potential of the River Nile for electricity generation. However, the plans for setting up the ESI were delayed due to the perceived lack of an effective market for electricity at the time (Gore, 2009).

It was not until 1936 that the development of the ESI was revisited when the head of the Kenya-based East African Power and Lighting Company (EAP&L) and Governor Philip Mitchell held discussions about the opportunities for electricity generation and distribution in the Uganda Protectorate. In the same year, EAP&L was awarded a license to generate and distribute electricity in Uganda. EAP&L installed two thermal (diesel) generating stations in Kampala and Entebbe in 1938, marking the start of commercial electricity supply in Uganda and thereafter, a third thermal station was commissioned (Mawejje *et al*., 2013). The 1946 Uganda development plan placed much emphasis on the development of the ESI to drive an export-oriented and agricultural-based industrial economy (Mawejje *et al*., 2013). The plan was to start a large hydroelectricity project and the creation of a quasi-independent body to oversee developments in the generation, transmission and

distribution of electricity. Thus in 1948, the Uganda Electricity Board (UEB) was created as a vertically integrated natural monopoly, initially with a vision to supply electricity to the wider East African region.

The Electricity Supply Industry in Uganda was planned around exploiting the immense potential of the River Nile. The prioritised dam projects were Owen Falls, Bujagali Falls and Ripon Falls. However, the Owen Falls project (now Nalubaale) was deemed superior to the two other potential locations on technical grounds. The construction of the Owen Falls dam commenced in 1950. In 1954, the first two generating units were commissioned, each with an installed capacity of 15 MW. Additional units were added until the last one was installed in 1968 bringing the total capacity to 150 MW, which was later expanded to 180 MW (Gore, 2008).



Figure 2-1: Nalubaale Hydropower Plant, Jinja, formerly Owen Falls (photo by UEGCL).

It was widely expected that the electricity project would spur economic and social transformation in Uganda and East Africa in general. However, in the immediate years following the completion of the Owen Falls Dam, the anticipated benefits were not realised because of the financial and technical constraints that UEB faced, the emergence of civil wars in Uganda, and the political unrest that followed the post-independence years (the 1970s and early 1980s), coupled with the weakening interest from major project financiers, including the World Bank, meant that the Owen Falls project did not take off on time.

The UEB by then assumed both a regulatory role and a full monopoly to generate, transmit, distribute, export and import electricity in Uganda. Due to the electricity monopoly, the Electricity Supply Industry – which determines the economic growth of the country – was dwindling due to the inadequate capacity of UEB to generate, transmit and distribute electricity. This was coupled with a high level of corruption and debts for the institution.

What followed was a near collapse of the ESI in Uganda. The generation infrastructure was rundown, capacity at Owen Falls Dam fell to a mere 60 MW and customer numbers fell by 25% (Engurait, 2005). It was not until 1986 that interest in developing Uganda's Electricity Supply Industry was rekindled.

2.1.2 Electricity grid coverage and contribution before the first ESI reform in 1999

Uganda had suffered decades of inadequate and insecure supply during the conflicts of the 1960s, 1970s and 1980s. At the heart of the issue was inadequate supply, which stood at just 150 MW in 1990 – though in reality power supplied was much lower, due to the low availability factor. The national power utility did not perform well, contributing to high technical and commercial losses, and unable to invest in the new capacity needed. Adding to these structural and institutional issues, Uganda's limited installed capacity was primarily hydro-based, making it vulnerable to drought. Increasing capacity was clearly of the utmost importance for sector recovery and economic growth (Godinho and Eberhard, 2019).

Owen Falls, now referred to as Nalubaale, was refurbished and extended to raise its capacity to 180 MW toward the end of the 1990s. Construction of a second power plant, Kiira, began in 1993. Comprising of five 40 MW units (200 MW total), all units were commissioned by 2003. During the 1990s, power outages and brownouts (voltage drops) were frequent, and the quality of power supply was poor, with severe costs to the economy and customers. Access to electricity was as low as 5% in 1991 (Godinho and Eberhard, 2019).

2.2 Reforms in the ESI Policy, Legal and Institutional Structure from 1999 to 2022

2.2.1 The first ESI reforms

In 1993, the Government of Uganda, with the support of the World Bank under the Public Enterprise Reform and Divestiture Programme, undertook major reforms that led to the divestiture of many public enterprises. Many state-owned companies were privatised, though UEB was not initially among them.

Six years later in June 1999, the decision not to privatise the UEB was reversed. The Government put in place a Power Sector Restructuring and Privatisation Strategy, thus giving birth to the first ESI reforms to solve six (6) major challenges faced by UEB, namely:

1) Make the sector commercially viable;
2) Reduce dependence on Government subsidies;
3) Improve access to electricity including rural electrification;
4) Improve reliability and quality of supply;
5) Attract private investors; and
6) Take advantage of the regional markets.

A new legislation, the Electricity Act, Cap.145 was passed in 1999 and this formed the basis for the unbundling of the UEB monopoly into three separate segments for generation, transmission and distribution. While the generation and distribution segments were opened to private sector participation, the transmission segment remained wholly Government-owned. In March 2001, the UEB was unbundled into three companies namely:

1) Uganda Electricity Generation Company Ltd (UEGCL);
2) Uganda Electricity Transmission Company Ltd (UETCL); and
3) Uganda Electricity Distribution Company Ltd (UEDCL).

2.2.2 Policy, Legal and Institutional Framework

To enable the reform process in the Electricity Supply Industry to proceed, a new Electricity Act was enacted in 1999, repealing the 1964 one. The formulation of the Electricity Act, Cap. 145, provided the legal and institutional framework of the ESI. In addition, the Rural Electrification Trust Fund was created to promote pro-poor electricity access. The same Act established the Electricity Regulatory Authority (ERA) to oversee the ESI and regulate the operations of the UEB successor companies and any licensed private investors in the ESI.

Other organs such as the Electricity Disputes Tribunal, and the Rural Electrification Agency (REA) / the Rural Electrification Board (REB) were established to handle the resolution of sector disputes and to promote rural electrification programmes, respectively.

Following the above reforms, the ESI institutional structure in Uganda comprised of five main segments:

1) Policy and Promotion (Ministry of Energy and Mineral Development)
2) Regulation (Electricity Regulatory Authority)
3) Generation (UEGCL, IPPs and PPPs).
4) Transmission (UETCL)
5) Distribution (UEDCL, UMEME Limited, etc.)

The generation segment has a combination of GoU-owned power plants, Independent Power Producers (IPPs), and Public-Private Partnerships (PPPs). The transmission segment was wholly owned by the Government. The distribution segment, just like generation, was also liberalised and has private players as well as the Government's distribution company – the Uganda Electricity Distribution Company Ltd (UEDCL) as illustrated in Figure 2-2.

However, there were some few instances where a company was licensed as a vertically integrated natural monopoly to generate and distribute electricity in isolated and off-grid areas such as Kalangala Infrastructure Service Limited in Kalangala islands, West Nile Rural

Electrification Company Limited in West Nile Region and Hydromax Limited in some villages located on a radius of one (1) kilometre of the power evacuation line from the generation site to the 33/11 kV Kinubi substation in Hoima District.

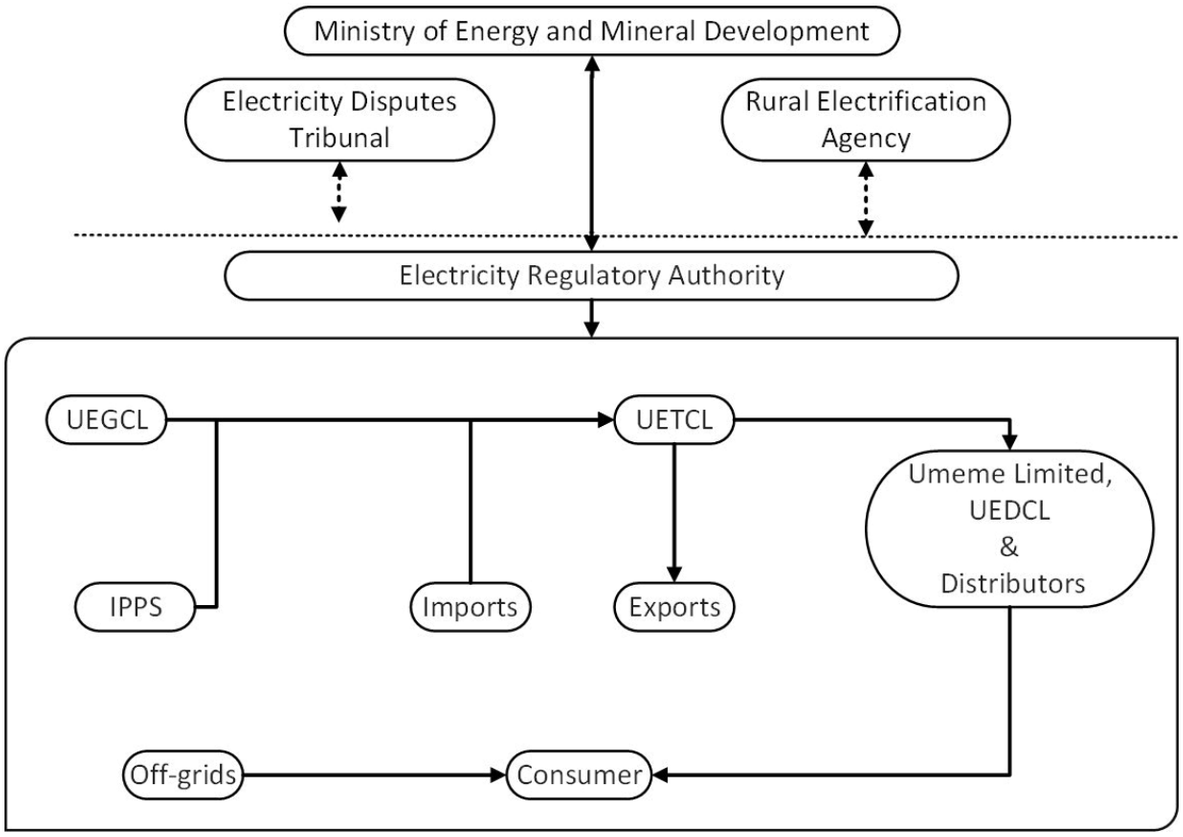


Figure 2-2: Organisation of the Electricity Supply Industry in Uganda after the first sector reform.

2.3 Current Institutional Structure of the Electricity Supply Industry

With the coming into force of the Electricity (Amendment) Act of 2022, the organisation of the Electricity Supply Industry changed. The most notable change is the unbundling of the transmission segment as follows:

1) Direct sale of electricity by the generator to the final customer/changes in the bulk supplier role.
2) Private sector Investment into the transmission segment.

1) Regulatory changes in a bulk supplier role

Before the Electricity (Amendment) Act, 2022, Section 56 (1) of the Electricity Act provided for a Bulk Supplier with the sole responsibility of transmission and sale of electricity in bulk, to distribution and sales companies. The bulk supplier has been UETCL only. However, from 2022 onwards, Section 56 of the Act was amended to allow for the direct sale of power to large consumers, distribution licensees and industrial parks in order to achieve reductions in costs by eliminating distribution and transmission costs inter alia and to promote for industrial development.

2) Private investment into the transmission segment

The Electricity (Independent Power Transmission) Regulations, 2023 provides for the refurbishment, upgrade or replacement of an existing transmission facility by a private developer, and the development of any new transmission facility by a private developer for a point-to-point line, transmission installations and interconnectors. Amendment may result in more investments in the sector by new investors, thus increasing pressure on the environment.

The current organisation of the Electricity Supply Industry in Uganda is shown in Figure 2-3 below.

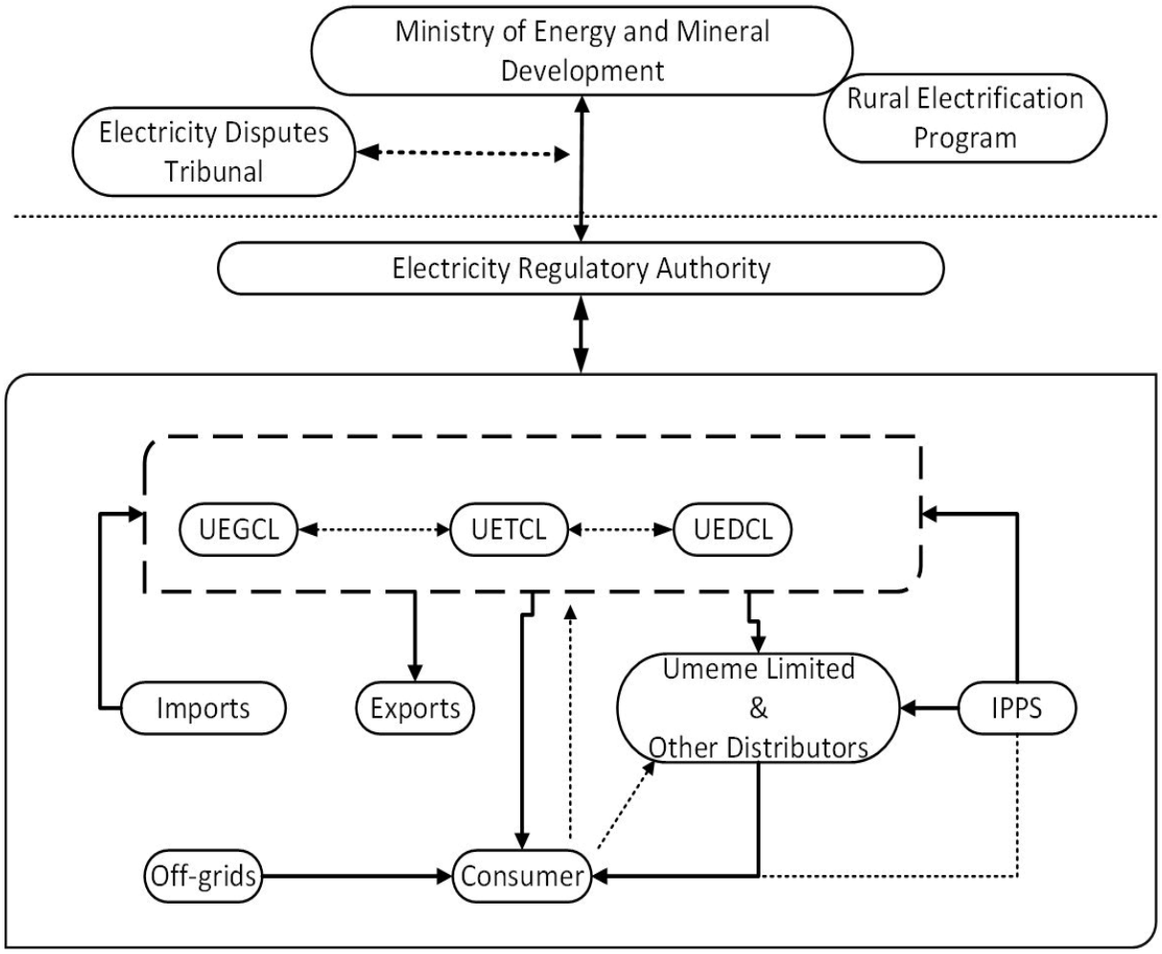


Figure 2-3: Organisation of the Electricity Supply Industry in Uganda after the Electricity (Amendment) Act, 2022.

2.3.1 ESI Contribution to National Development

The Electricity Supply Industry plays a crucial role in the economic development of any country, including Uganda. Some key aspects highlighting the importance of the Electricity Supply Industry to Uganda's national economy are as follows:

1) Industrialization and economic growth: Reliable and affordable electricity is essential for industrialization. It powers manufacturing processes, which, in turn, contributes to economic growth by creating jobs and increasing production. As of the financial year 2021/2022, the Electricity Supply Industry contributed 1.3% to Uganda's gross domestic product. In terms of job creation, the

sector directly employed more than 4,500 Ugandans as of 2023 (see Section 6.3.3 below for information about direct employment).

2) Productivity and Services: Electricity is a fundamental input for various sectors, including services, agriculture, and healthcare. It enhances productivity in offices, facilitates communication, and supports modern technologies.

3) Rural electrification and agriculture: Expanding the electricity infrastructure to rural areas can improve agricultural productivity by enabling the use of electric-powered machinery, irrigation systems, and processing facilities.

4) Quality of Life and Education: Access to electricity improves the quality of life for citizens. It supports lighting in homes, extends study hours, and enables access to information through electronic devices, contributing to educational development.

5) Healthcare Services: Electricity is vital for healthcare facilities. It powers medical equipment, refrigeration for vaccines and medicines, and facilitates the overall functioning of hospitals and clinics.

6) Business and Investment Climate: A reliable and stable electricity supply attracts foreign investments and supports the growth of local businesses. It enhances the overall business environment by ensuring consistent and affordable power.

7) Reducing Dependency on Traditional Energy Sources: Expanding the Electricity Supply Industry helps reduce dependence on traditional and often unsustainable energy sources, such as biomass and kerosene, leading to environmental and health benefits.

8) Infrastructure Development: The Electricity Supply Industry is a key driver for infrastructure development. It necessitates the construction and maintenance of power generation plants,

transmission lines, and distribution networks, contributing to overall economic infrastructure.

9) Revenue Generation: The Electricity Supply Industry generates revenue for the government through taxes and fees. Efficient management of the sector contributes to the overall fiscal health of the country.

10) Climate Change and Sustainability: Investing in sustainable and renewable energy sources within the Electricity Supply Industry aligns with global efforts to combat climate change. Uganda's commitment to clean and green energy can enhance its international standing and contributes to a sustainable future.

2.3.2 ESI Regulatory Frameworks

Natural resources exploited for energy purposes in the Electricity Supply Industry are regulated based on several policies, laws and regulations. These frameworks are readily available in the public domain and the key ones governing the Electricity Supply Industry include:

(1) The Constitution of the Republic of Uganda; under the National Objectives and Directive Principles of the State Policy - on the Environment; states that "The State shall promote and ***implement energy policies that will ensure that people's basic needs and those of environmental preservation are met"***. Article 39 provides for the right to a clean and healthy environment, thus; "Every Ugandan has a right to a clean and healthy environment".

(2) The Electricity Act, Cap 145 of Laws of Uganda. The Act provides for the establishment of the Electricity Regulatory Authority; provides for its functions, powers and administration; to provide for the generation, transmission, distribution, sale and use of electricity; to provide for the licensing and control of activities in the Electricity Supply Industry; to provide for plant and equipment and for matters relating to safety; to liberalise and introduce competition in the Electricity Supply Industry, among others.

(3) The National Environment Act No. 5 of 2019 mandates NEMA to coordinate and prepare a National State of the Environment Report (SOER) every two years. In the same law under Section 11, lead agencies such as the ERA are required to also prepare their sector SOER every two years to feed into the National SOER.

(4) The Energy Policy for Uganda 2023 aims to ensure a sustainable, adequate, affordable, competitive, secure, and reliable supply of energy at the least cost geared to meet national and county needs while protecting and conserving the environment.

(5) Electricity Connections Policy (2018) aims to increase access and provide cleaner energy for Ugandans. The goal of the policy is to achieve a 60% level of access to electricity for Uganda by 2027.

(6) Other relevant national legislations are triggered by either the location of the subject electricity installation or the resource used in the production of electricity. They include but are not limited to;

a) Land Act, Cap 227

b) Water Act, Cap 152

c) National Forestry and Tree Planting Act, 2003

d) Uganda Wildlife Act, 2019

e) Occupational Safety and Health Act, 2006

f) National Environment (Wetlands, River Banks and Lake Shores Management) Regulations, 2000

ERA coordinates with the subject ministries, departments, and agencies (MDAs) of the Government mandated to manage a specific segment of the environment, to secure the use rights over the natural resources, ecosystems and/or protected areas, in which the proposed energy project will be located or will use in the production of electricity. Therefore, interagency collaboration is an important regulatory mechanism of promoting Electricity Supply Industry developments and operations. These MDAs include, but are not limited to, NEMA, DWRM, UWA, NFA, Occupational Health and Safety Department, CGV, etc. ERA has so far signed MoUs with NEMA, NFA and DWRM.

2.3.3 Relevant International Legal Frameworks

Uganda is a party to several international conventions relevant to the Electricity Supply Industry, including:

- African Convention on the Conservation of Nature and Natural Resources, 1968, revised 2003.
- Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar), 1971, amended by the 1982 Protocol and the 1987 Amendment to the Convention.
- Convention on Protection of World Cultural and Natural Heritage, 1972.
- Convention on the Conservation of Migratory Species (Bonn Convention), 1979.
- Basel Convention on the Control of Transboundary Movements of Hazardous Waste and their Disposal, 1989.
- United Nations Framework Convention on Climate Change (UNFCCC), 1992, the Kyoto Protocol, 1997, and the Paris Agreement, 2015.
- United National Convention on Biological Diversity, 1992.
- Stockholm Convention on Persistent Organic Pollutants (POPs), 2001.

In terms of labour and working conditions in the Electricity Supply Industry industry, the core labour standards as laid out in the eight fundamental conventions of the International Labour Organization (ILO) have been ratified by Uganda:

- Forced Labour Convention, 1930 (No. 29).
- Freedom of Association and Protection of the Right to Organise Convention, 1948 (No. 87).
- Right to Organise and Collective Bargaining Convention, 1949 (No. 98).
- Equal Remuneration Convention, 1951 (No. 100).
- Abolition of Forced Labour Convention, 1957 (No. 105).
- Discrimination (Employment and Occupation) Convention, 1958 (No. 111).

- Minimum Age Convention, 1973 (No. 138).
- Worst Forms of Child Labour Convention, 1999 (No. 182).

Uganda has also signed many other international agreements and commitments that may be relevant for projects in the sector.

2.4 Activities of the Electricity Regulatory Authority

The Electricity Regulatory Authority (ERA) is a statutory body established under Section 3 of the Electricity Act, Chapter 157, Laws of Uganda, to regulate the generation, transmission, distribution, sale, export and import of electrical energy in Uganda. Specific functions as listed under Section 9 of the Act are:

(a) To issue Licences for –
  (i) The generation, transmission, distribution or sale of electricity; and
  (ii) The ownership or operation of transmission systems;
(b) to receive and process applications for licences;
(c) to prescribe conditions and terms of licences issued under this Act;
(d) to modify licences issued under this Act;
(e) to make and enforce directions to ensure compliance with licences issued under this Act;
(f) to establish a tariff structure and to investigate tariff charges, whether or not a specific complaint has been made for a tariff adjustment;
(g) to approve rates of charges and terms and conditions of electricity services provided by licensees;
(h) to review the organisation of generation, transmission and distribution companies or other legal entities engaged in the generation, transmission and distribution of electricity to the extent that that organisation affects or is likely to affect the operation of the electricity sector and the efficient supply of electricity;
(i) to develop and enforce performance standards for the generation, transmission and distribution of electricity;

(j) to encourage the development of uniform electricity industry standards and codes of conduct;
(k) to establish a uniform system of accounts for licensees;
(l) to prepare industry reports and to gather information from generation, transmission and distribution companies;
(m) to prescribe and collect fees;
(n) to provide for the procedure for investment programmes by transmission and distribution companies;
(o) to approve standards for the quality of electricity supply services provided;
(p) To approve codes of conduct in respect of the operation of transmission and distribution systems;
(q) to prescribe standardised feed in tariffs for renewable energy systems generating up to a maximum capacity of fifty megawatts or such other capacity as may be determined by the Authority;
(r) to undertake consultancies, research and studies;
(s) to advise the Minister on any matter relating to the electricity sector;
(t) to acquire information and carry out investigations relating to any of the functions of the Authority; and
(u) to perform any other function that is incidental or consequential to the functions of the Authority under this section, or as may be conferred on the Authority by other law.

In effect, the Act vests in ERA the functions of control of activities in the Electricity Supply Industry in Uganda.

In execution of its statutory and regulatory functions of issuing licenses for; the generation, transmission, distribution or sale of electricity; and the ownership or operation of transmission systems, ERA is also required under Section 11 of the National Environment Act, 2019, to discharge the functions of a lead agency as follows:

(1) Plan, regulate and manage the segment of the environment within its mandate;

(2) Carry out a strategic environmental assessment in accordance with Section 47;

(3) Prepare an environmental action plan in accordance with Section 45;

(4) Prepare the state of environment report in accordance with Section 46;

(5) Undertake environmental inspections and review environment assessments and environmental audits in accordance with this Act [National Environment Act, 2019] and any other applicable law.

(6) Ensure that any activity undertaken in its area of jurisdiction is in compliance with this Act;

(7) Implement the decisions of the Authority [NEMA] with respect to the segment of the environment under its mandate;

(8) Report on progress quarterly and account to the Authority [NEMA] for execution of its role in relation to environmental management within three months after the end of the financial year; and

(9) Implement and enforce the provisions of this Act.

The above functions of ERA as a lead agency under the National Environment Act, 2019, are further underscored in the Electricity Act, under Licensing as outlined below.

2.4.1 Licensing

1. Section 29(2)(f) requires that the Notice of Intended Application shall as far as possible contain; "a description of the impact of the project on electricity supply, social economic, cultural heritage, the environment, natural resources and wildlife" among others.
2. Subsections 33(1)(g), (h) and (i) require that an application for a license shall be submitted to the Authority and shall contain;
   (1) the results of assessments, including environmental impact assessment and studies carried out and reports of those assessments and studies"
   (2) "the impacts of the project on private interests, including the interests of affected landowners and holders of other rights." It

is understood that the impacts referred to in this paragraph are those studied and documented in the form of a Resettlement Action Plan (RAP) and associated valuation reports during feasibility studies of the project.

(3) "consents and permits required under any other law". In this regard, ERA requires the consent and/or permits from the principal lead agencies responsible for the management of specific segments of the environment thus NEMA for environmental clearance, Directorate of Water Resources Management (DWRM) for water permits, et cetera (to secure use rights on the subject resources to be used in the successful development and operation of power project(s). Nevertheless, the consents and/or permits come with conditions and inherent responsibility.

3. Section 37(1)(b), (c) and (j), respectively, require the ERA, in granting or rejecting an application for a license, to take into consideration, as far as is adequate for the project applied for:

   (1) "The impact of the operations of the undertaking on the social, cultural and recreational life of the community."

   (2) "the need to protect the environment and to conserve the natural resources"

   (3) "other public and private interests affected by the operation for which the license is required"

A license is a document which grants special permission to a specified company to develop and run power generation station and transmission and distribution network specified in the license, including conditions and rules of operation. ERA derives its powers to issue, modify or revoke licenses from the Electricity Act, Cap 157, Laws of Uganda. Under Sections 9(a), (b), (c) and (d) one of the key functions of ERA is to receive and process applications for licenses for the generation, transmission, and distribution sale of electricity. It also empowers ERA to prescribe conditions and terms of licenses and to modify licenses issued under the Act.

The objectives of licensing electricity projects are:

a) To attract private capital and management expertise by providing investors and operators a certain level of certainty and commitment as a safeguard to their investments.

b) Commitments to investors are further strengthened by obligations assumed by the Bulk Power Purchaser/Supplier in the PPA and the guarantees of the GoU under the Implementation Agreements and associated instruments.

c) To guarantee consumers at least a minimum level of services, service standards, network growth and an equitable tariff.

d) To provide a basis for monitoring of licensees and enforcement of investor/operator obligations as ERA generally regulates by contract.

Types of Licences Issued by ERA include:

i) Generation Licence

ii) Transmission Licence

iii) Bulk Supplier Licence

iv) System Operator Licence

v) Distribution Licence

vi) Sale Licence

vii) Export and Import Licence.

Interested power project developers can invest in Uganda's Electricity Supply Industry through a solicited or unsolicited licensing process.

a) Solicited Licensing Process: The Electricity Regulatory Authority, through a fair, open and competitive process in accordance with procedures prescribed under the Electricity Act and supporting regulations, invites applications for licenses to generate electricity.

b) Unsolicited Licensing Process: Licensing of Independent Power Producers (IPPs), under the unsolicited route goes through a two-tier process which includes i.e., the feasibility permit stage; and, the licensing stage (construction and operation).

As per the Electricity (Application for Permit, Licence and Tariff Review) Regulations, 2007, the licensing of electricity projects in Uganda covers the following steps/procedures:

1) Notice of intended application. A person who intends to establish a project for which a licence is required under the Act, starts with submitting to the Authority a notice of intended application. The notice of intended application contains among others a description of the impact of the project on electricity supply, socioeconomics, cultural heritage, the environment, natural resources and wildlife.
2) Publication of notice of intended application. The Authority within thirty days after receipt of a complete notice of intended application, cause the notice to be published in the Gazette and in at least one national newspaper of wide circulation in Uganda. The Authority invites directly affected parties and affected public agencies to make comments on the notice within a fixed period of not less than thirty days after the date of publication of the notice.
3) Grant of a permit. The Authority may, within thirty days (30) after the expiration of the notice, issue a feasibility permit to the intended applicant, taking into account the responses and comments made by the applicant. The permit issued allows the intended applicant to carry out studies including the environmental and social impact assessment, and any other activities that may be necessary to enable the intended applicant to prepare an application for a licence.
4) Renewal of permit. The Authority may renew a permit on such terms and conditions as it may determine.
5) Application for licence. An application for a licence under the Act is submitted to the Authority and contains among others the results of assessments, including environmental impact assessments and studies carried out and reports of those assessments and studies. The application is also accompanied by an evaluation by the applicant of all the comments from affected parties and affected public agencies.
6) Publication of application for licence. The Authority within forty days after receipt of a complete application for a licence, cause a notice of the application to be published in the Gazette and in at

least one national newspaper of wide circulation in Uganda. The notice published contains among others a description of the nature and location of the proposed undertaking and invites directly affected parties and public agencies in the area affected by the project to submit in writing, any objection and comments on the project within thirty days after publication of the notice.

7) Licences through a competitive process. Among others, where the Government or a government agency initiates a project under the Electricity Act which is likely to benefit from public finances, the Authority through a fair, open and competitive process, invite applications for licences in accordance with the Public Procurement and Disposal of Public Assets Act, 2003.

8) Grant of licence. The Authority shall, in granting a licence, take into consideration the policies of the Government, matters provided for under the Act and any other relevant law, environmental and social aspects of the project, the report of the public hearing and any other matter that the Authority may consider to have a bearing on the operations of the applicant. The license allows the developer to proceed with the construction and operation phase of the project. In the licensee, specific conditions of environmental and social aspects are incorporated.

9) Refusal to grant licence. The Authority, where it refuses to grant a licence, give the applicant a statement of its reasons in writing for the refusal within thirty days (30) after the refusal. A person aggrieved by the refusal of the Authority to grant a licence may appeal to the Electricity Disputes Tribunal.

10) Transfer and assignment of licence. A licensee who intends to transfer or assign a licence submits applies to the Authority. The Authority within thirty days (30) after receipt of an application transfers or assigns the licence.

The wider licensing framework for electricity projects is illustrated in Figure 2-4 below. During the licensing process, the Electricity Regulatory Authority consults several institutions such as the Directorate of Water Resources Management, the Uganda Wildlife Authority, and the National Forestry Authority. The level and form of consultation are dependent on the nature of the project and, the location of the project among others.

These institutions provide the necessary approvals, certificates, and permits to guide the implementation and operationalization of the projects. ERA is also consulted by NEMA prior to issuing terms of reference and Certificate of Approval of Environmental Impact assessment for projects proposed in the Electricity Supply Industry. ERA under Section 11(f) is required to ensure that any activity undertaken in its area of jurisdiction is in compliance with the National Environment Act, 2019.

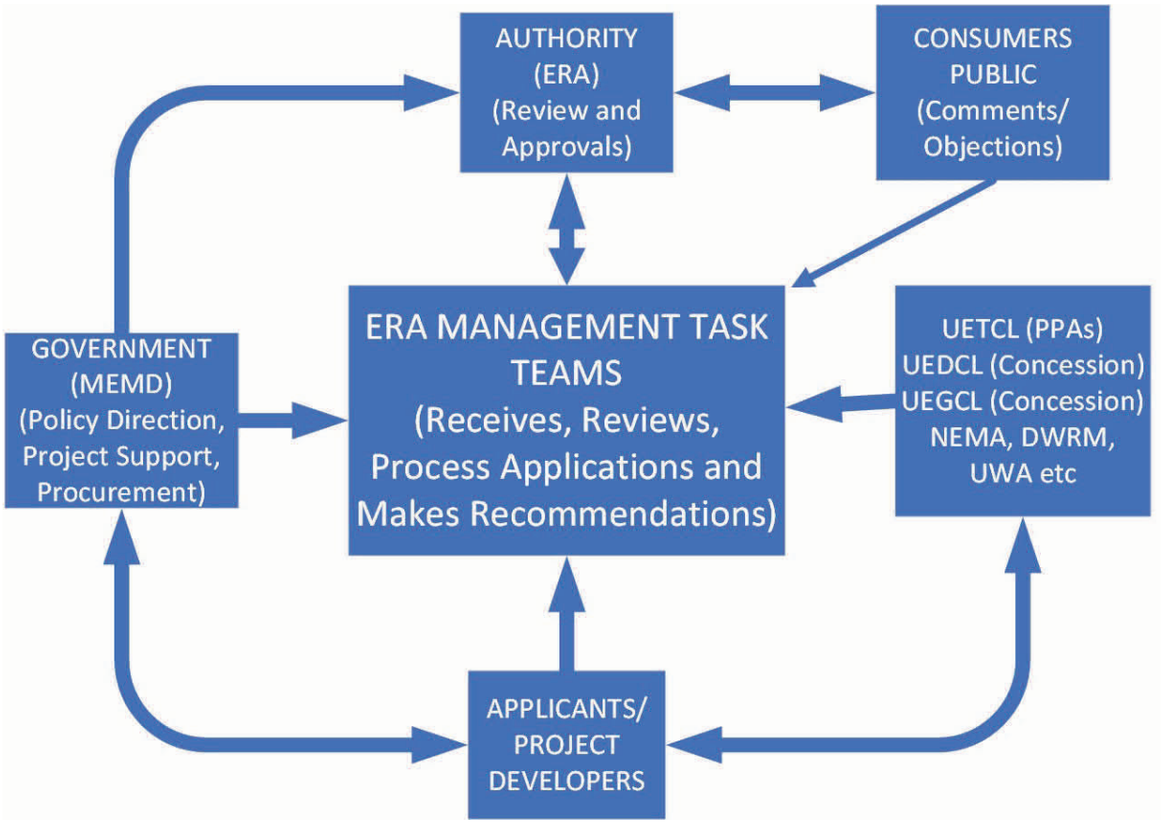


Figure 2-4: Licencing framework of electricity projects in Uganda.

2.4.2 Enforcement of Compliance

Section 10 of the Electricity Act establishes the functions of ERA, among which include:

1) To make and enforce directions to ensure compliance with licenses issued under the Act.
2) To develop and enforce performance standards for the generation, transmission and distribution of electricity.

The enforcement approach taken by ERA is staged:

i) an informal approach is taken and where unsuccessful,

ii) a formal enforcement action and mechanism is undertaken.

Figure 2-5 below shows the enforcement approach with the different escalation stages at which the different enforcement actions are implemented in line with the Electricity Act.

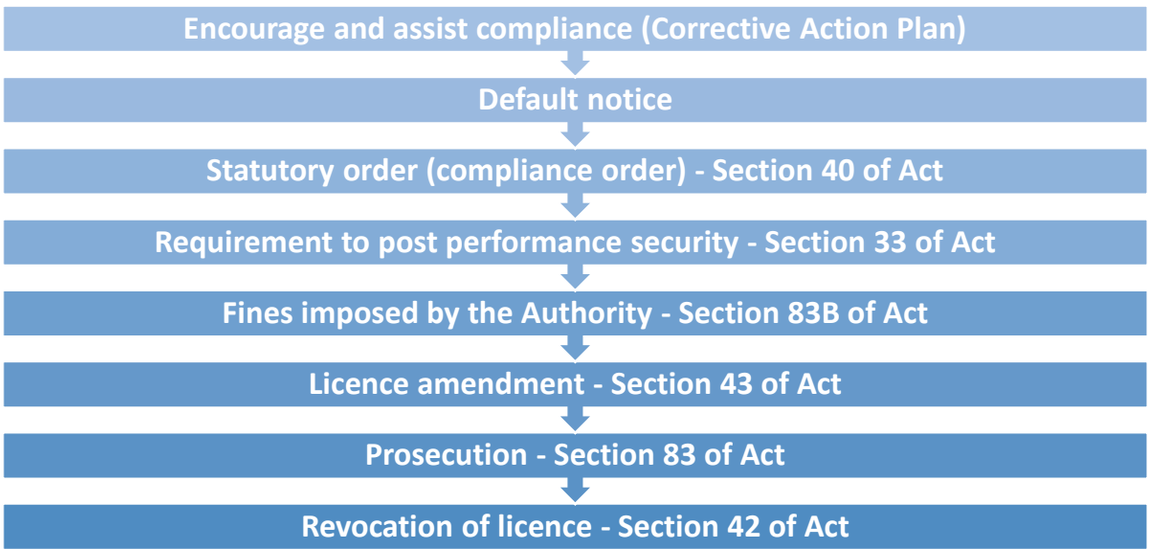


Figure 2-5: Escalation of enforcement actions

The Electricity Regulatory Authority quarterly undertakes site inspections to assess and monitor the compliance of different licensees with the different conditions provided for in the license, and several other certificates, approvals, and permits obtained by the licensees from the different Authorities.

These licences have terms and conditions that must be adhered to over the license period, including the obligation to submit monitoring reports to ERA on the environmental matters affecting the respective operations.

In addition, each licensee is under the obligation to comply with the Certificate of Approval in respect of the environmental aspects issued by the National Environment Management Authority (NEMA). The environmental certificate outlines the minimum environmental conditions that the licensee/developer shall comply with during the construction and operation of the project. The Electricity Regulatory Authority, being

the Regulator of the Electricity Supply Industry and thus the Lead Agency on matters of environmental management in the sector, is required under Section 11(f) of the National Environment Act, 2019, to ensure that activities related to the generation of electricity among others are conducted in conformity to the National Environment Act, 2019.

Follow-up and monitoring of license terms and conditions and specifically the environmental requirements for licensees are achieved through the following means, among others:

- Quarterly offsite monitoring reports;
- On-site inspection exercises;
- Compliance assistance meetings; and
- Enforcement of compliance.

ERA receives approximately 240 monitoring reports annually from licensees and permit holders and ERA undertakes approximately 180 inspections of electricity installations annually to ensure compliance with license terms and conditions that include environmental requirements, among others.

2.4.3 Decommissioning of Electrical Installations

Subsection 49(2) provides that the electrical removal of installations at the expiry of a license term shall be in accordance with the National Environment Act and any other relevant law. In 2018, ERA approved the Electricity (Decommissioning Power System Installations) Guidelines, 2018, for use by licensees. These provide guidance to Licensees on decommissioning power system installations that are considered inappropriate for further operations, to ensure protection of public health and the environment. Guidance is given on the following aspects; legal framework, decommissioning process, decision to decommission, management of the decommissioning exercise, decommissioning plan, environmental and social management plan, public participation, decommissioning report, statement of liability, abandoned installations and closing a decommissioning exercise.

2.4.4 Land Compensation

Sections 67 to 71 of the Electricity Act, outline the mandate of ERA regarding land acquisition and compensation, in respect to licensed power projects. This part of the Electricity Act underscores the significance of ERA to consider resettlement action plan (RAP) studies conducted during feasibility studies of a power project before granting of a license, to ensure fair and adequate compensation is planned for the property to be affected and in conformity with Article 26 of the Constitution of Uganda.

The Constitution of Uganda enshrines the right to property under Article 26. The only acceptable compulsory deprivation from the right to property is where a person's land is required for public use. In that case, an individual or group dispossessed of their land rights must be paid compensation which must be "prompt payment of fair and adequate compensation, prior to the taking of possession or acquisition of the property".

In matters of compensation, ERA relies on the advice or approval of the Chief Government Valuer (CGV), the competent Authority on land value matters.

2.5 Collaboration with Other Agencies

ERA collaborates with Government ministries, departments, and agencies in the discharge of its mandate. ERA has signed MoUs with the National Environment Management Authority, the Directorate of Water Resources Management, and the National Forestry Authority. The specific objectives of the individual MoUs differ but the aim is to facilitate cooperation and mutual assistance between the ERA and other agencies of Government in the discharge of their respective statutory obligations, such as to avoid the imposition of unnecessary regulatory burdens on businesses.

These MoUs have facilitated cordial collaboration and many activities between ERA and the different institutions as highlighted below.

2.5.1 ERA and NEMA Collaboration

Review of environmental assessment reports

ERA reviews and provides formal feedback on environmental reports received from NEMA namely; scoping reports and terms of references for ESIAs as well as ESIA reports that may lead to the issuance of a Certificate of Approval of ESIA by NEMA. ERA also reviews Annual Environmental Audit reports, which need to be undertaken by entities with Certificates of Approval.

Lead agency role

ERA has since 2019 discharged successfully the lead agency role under the National Environment Act, 2019, including accounting to NEMA on an annual and quarterly basis in a timely manner.

Site inspection

NEMA and ERA have conducted project site inspections for generation projects and transmission lines as and when the need arises.

2.5.2 ERA and DWRM Collaboration

ERA initiated and has successfully implemented training and capacity building activities supported by development partners (e.g., NVE, GET FiT) where DWRM is on board namely:

i. Safety of hydropower dams and waterways.
ii. GET FiT Knowledge Sharing.
iii. Environmental Flow Working Group.
iv. Site inspection and monitoring compliance of electricity projects.
v. Hydrological Information Sharing.
vi. Issuance of water and construction permits; DWRM considers and issues water and construction permits to ERA-licensed projects.

2.5.3 ERA and NFA Collaboration

Information sharing between NFA and ERA

ERA has benefited from spatial information shared by NFA in the compilation of this State of the Environment Report. This spatial information also formed part of the baseline information for the establishment of ERA's GIS information database and unit.

ERA's CSR tree planting project

Over the years, ERA has been able to have access to land in different Central Forest Reserves to plant trees to restore degraded catchment areas for selected licensed hydropower plants, namely:

i. Fifteen (15) hectares (37 acres) in Bujawe Forest Reserve located along River Buseruka in Western Uganda;

ii. Fifteen (15) hectares (37 acres) in Laura Central Forest Reserve located along River Nyagak in the West Nile Region;

iii. Fifteen (15) hectares (37 acres) in Ongom Central Forest Reserve located along River Achwa in the Northern Region; and,

iv. Fifteen (15) hectares (37 acres) in Wamale Central Forest Reserve located along the River Nile in the Central Region.

2.5.4 ERA and UWA Collaboration

Information Sharing

UWA and ERA collaborate on matters of licensing electricity projects in protected areas managed by UWA. UWA has supported ERA with information leading to the decisions on whether to license or not license projects in protected areas. There is a need to strengthen this collaboration with a MoU.

Conservation efforts and support by licensed projects to protected areas

The Rwenzori Mountains National Park is the main water source for more than ten (10) small hydropower projects with a combined installed capacity of over 80 MW. Projects like the Nyamagasani 1, Sindila and Ndugutu HPPs have provided important support to UWA through comprehensive baseline and monitoring surveys of illegal activities in the

national park as a basis for defining more efficient conservation measures (see e.g., Bulafu *et al*., 2021). These projects also supported UWA by financing the construction of two new ranger posts, one in Kasese District and one in Bundibugyo District, that were handed over to UWA to strengthen patrolling and monitoring of the national park.

The Siti 1 HPP extends slightly into the Mount Elgon National Park in an area previously managed as a plantation forest. The Siti 1 HPP supported UWA through a biodiversity offset with tree planting for the restoration of areas inside and near the national park.

2.6 ERA's Vision, Mission, and Core Values

2.6.1 Vision

"To be a recognized regulator in the promotion of sustainable electricity supply for socio-economic transformation."

2.6.2 Mission

"To regulate the electricity industry in accordance with applicable laws, policies, standards and international best practice".

2.6.3 Core Values

Professionalism, Integrity, Innovation, Transparency and Accountability, Fair and Equal opportunity, Stakeholder sensitivity and Teamwork.

2.7 Sector Overview

The electricity supply industry has three main segments before power reaches the final consumer (see Figure 2-6 below), namely:

a) The electricity generation segment;

b) The electricity transmission segment; and

c) The electricity distribution and supply segment.

The generation segment has a combination of the Government of Uganda-owned power plants, Independent Power Producers (IPPs), and Public-Private Partnerships (PPPs). The transmission segment is still wholly owned by the Government of Uganda, but it has also been liberalised. The distribution segment, just like generation, is also liberalised and has private players, as well as a Government of Uganda-owned distribution company – the Uganda Electricity Distribution Company Ltd (UEDCL).

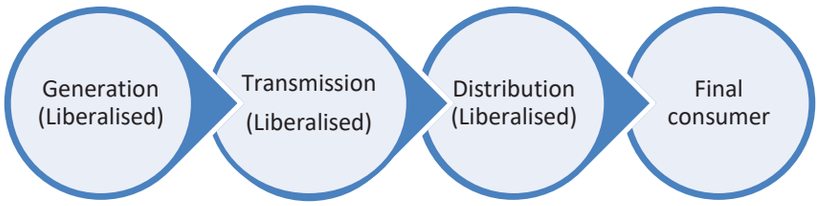


Figure 2-6: The main segments of the electricity supply industry in Uganda

2.8 Electricity Generation Segment

2.8.1 Generation Mix

Uganda's licensed, commissioned capacity was 1,847.50 MW as of December 2023 and hydropower accounted for 81.7% of the current generation mix as shown in Table 2-1 below. Virtually all capacity is connected to the national grid (99.7%).

Table 2-1: Generation mix and licensed, commissioned capacity as of 2023.

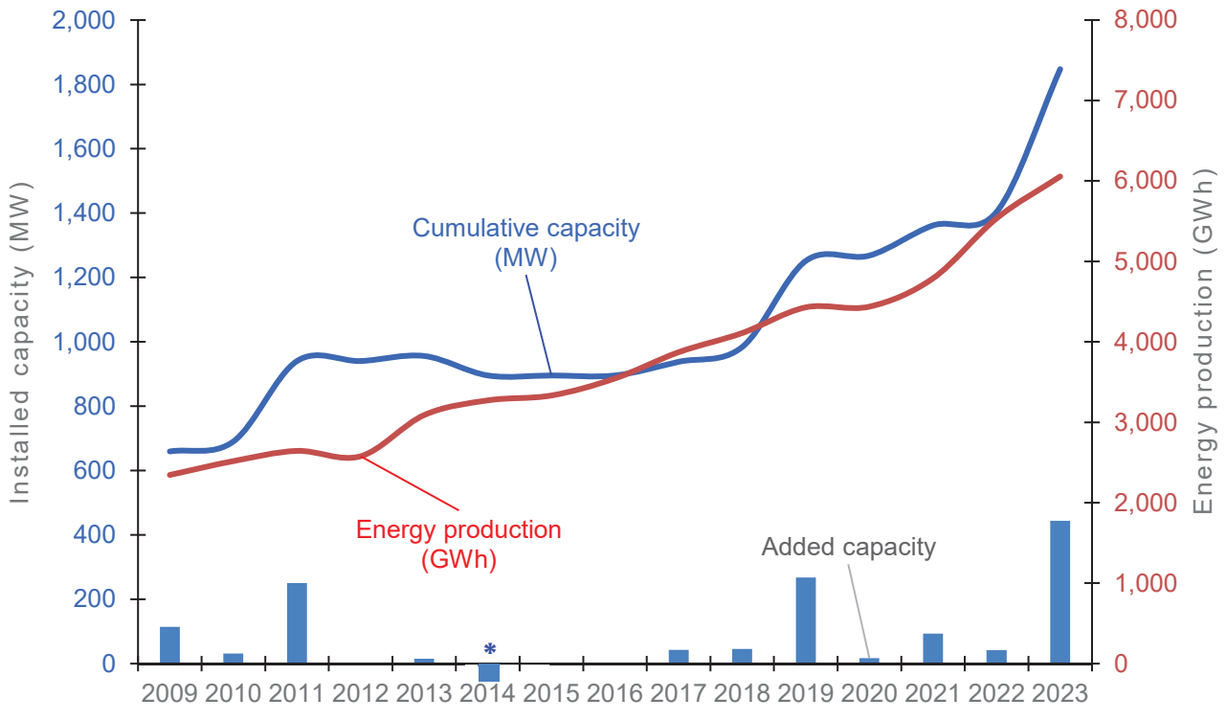
Generation sources	Licensed capacity (MW)	Percentage
Hydropower	1,510.30	81.7%
Co-generation (bagasse)	147.85	8.0%
Thermal (HFO)	100.00	5.4%
Solar photovoltaic	84.00	4.5%
Hybrids (off-grid)	5.35	0.3%
Total	1,847.50	100%

Source: ERA Database, 2023.

2.8.2 Growth in Generation Capacity and Actual Energy Production

The electricity generation capacity has registered significant growth from 659.4 MW in 2009 to 1,847.50 MW by the end of 2023. Actual energy production for the national grid increased from 2,345 GWh in 2009 to 6,056 GWh in 2023 as shown in Figure 2-7 below.

The difference between MW and GWh is that megawatt (MW) measures the capacity to provide electricity, while gigawatt hours (GWh) or megawatt hours (MWh) is a measure of electricity produced. For instance, if a unit with a capacity of 1 MW runs for 1 hour, then 1 MWh of electricity will be produced. If the unit of 1 MW capacity runs for 1,000 hours, then 1,000 MWh will be produced, which equals 1 GWh.



* In 2014, generation capacity was reduced by 60.5 MW (closing of thermal fossil fuel capacity).

Figure 2-7: Change in cumulative installed capacity, electricity generation per year, and added generation capacity per year from 2009 to 2023 (source: ERA Database, 2023).

2.8.3 Electricity Generation Sources in Uganda

The four main generation sources for grid electricity are:

1) Hydropower
2) Co-generation (combined heat and power based on biomass)
3) Thermal fossil fuel (heavy fuel oil and diesel)
4) Solar photovoltaic

The smallest (off-grid) generation sites combine the above sources such as solar-thermal (diesel) hybrid, and hydropower-thermal (diesel) hybrid. These hybrids for isolated grid generation are excluded in Figure 2-8.

Figure 2-8 shows the capacity and actual generation for the four main sources of grid electricity. Further information about these generation sources, their contributions to the generation mix, locations (both operational and planned) and general layout are discussed below.

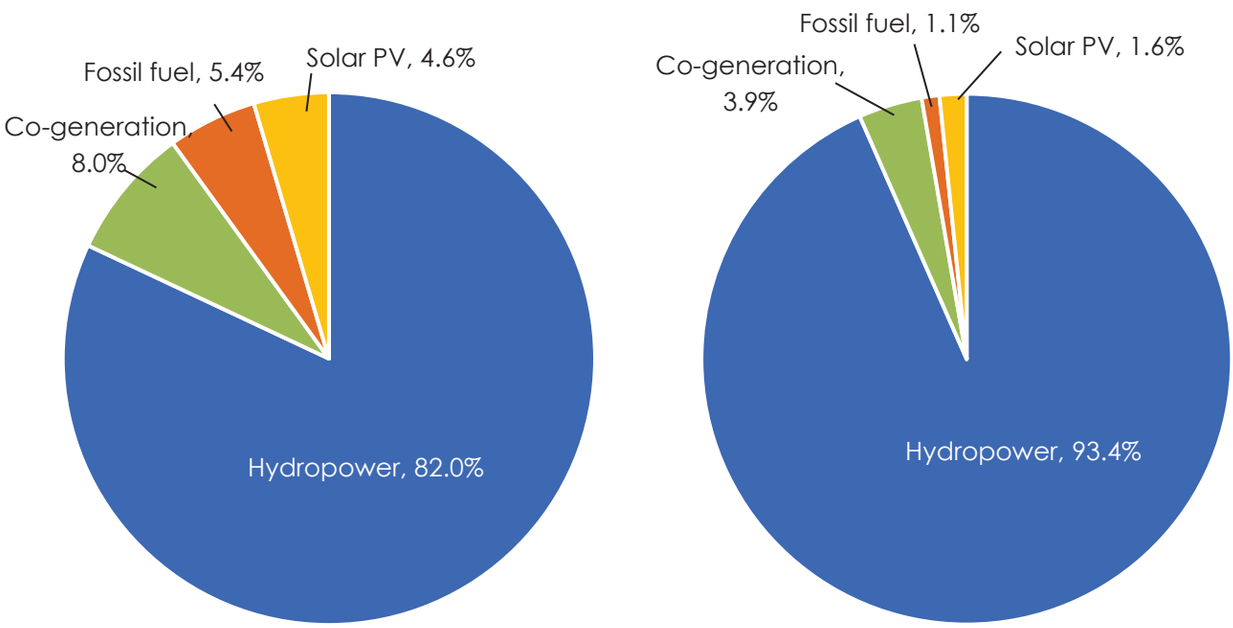


Figure 2-8: Proportion of installed capacity (left diagram) and actual generation (right diagram) in 2023 for the four sources of grid electricity: hydropower, co-generation (biomass), solar PV, and fossil fuel (source: ERA Database, 2023).

2.8.4 Hydropower

As of 2023, there were thirty-six (36) operational sites using the river flow to generate electricity, with a combined licensed capacity of 1,510.93 MW (on-grid and off-grid hydropower combined), contributing 82% of Uganda's generation mix. The size of the hydropower projects varies hugely from vary large structures on the Victoria Nile to much smaller structures on various mountain rivers (see Figures 2-9 and 2-10). Of the 36 projects, five (5) large hydropower projects contribute 80.3% of the hydropower capacity (1,213 MW) and the rest is from 26 small hydropower projects (13.9%), and two (2) medium-sized hydropower projects (5.8%). The two (2) off-grid mini hydropower projects and the one (1) off-grid micro hydropower project play an important role locally but contribute to less than 0.001% of the total hydropower capacity, see Table 2-2 below.

Table 2-2: Licensed, commissioned hydropower capacity in operation in 2023.

Classification by capacity	Connectivity to the national grid		Sub-total (MW)	Percent-age
	Off-grid (MW)	On-Grid (MW)		
Large hydro	-	1,213.00	1,213,00	80.3%
Medium hydro	-	87.21	87.21	5.8%
Small hydro*	-	210.09	210.09	13.9%
Mini hydro	0.56	-	0.56	>0.001%
Micro hydro	0.06	-	0.06	>0.0001%
Total	**0.62**	**1,510.30**	**1,510.93**	**100%**

* Nyagak HPP (3.5 MW) was for several years considered off-grid but was recently connected to the national grid.

Source: ERA Database, 2023.

The locations of operational hydropower projects are shown in Figure 2-11. The on-grid and off-grid projects are shown in Figure 2-12. Further details on each project are included in Annex 3.



Figure 2-9: Kiira Hydropower Plant (200 MW), an example of a large hydropower project on the Victoria Nile (photo by UEGCL).



Figure 2-10: Weir and intake of Ndugutu Hydropower Plant (5.9 MW), an example of a small hydropower project on a river in the Rwenzori Mountains (photo by GET FiT Uganda).



Figure 2-11: Locations of operational hydropower projects by size category.

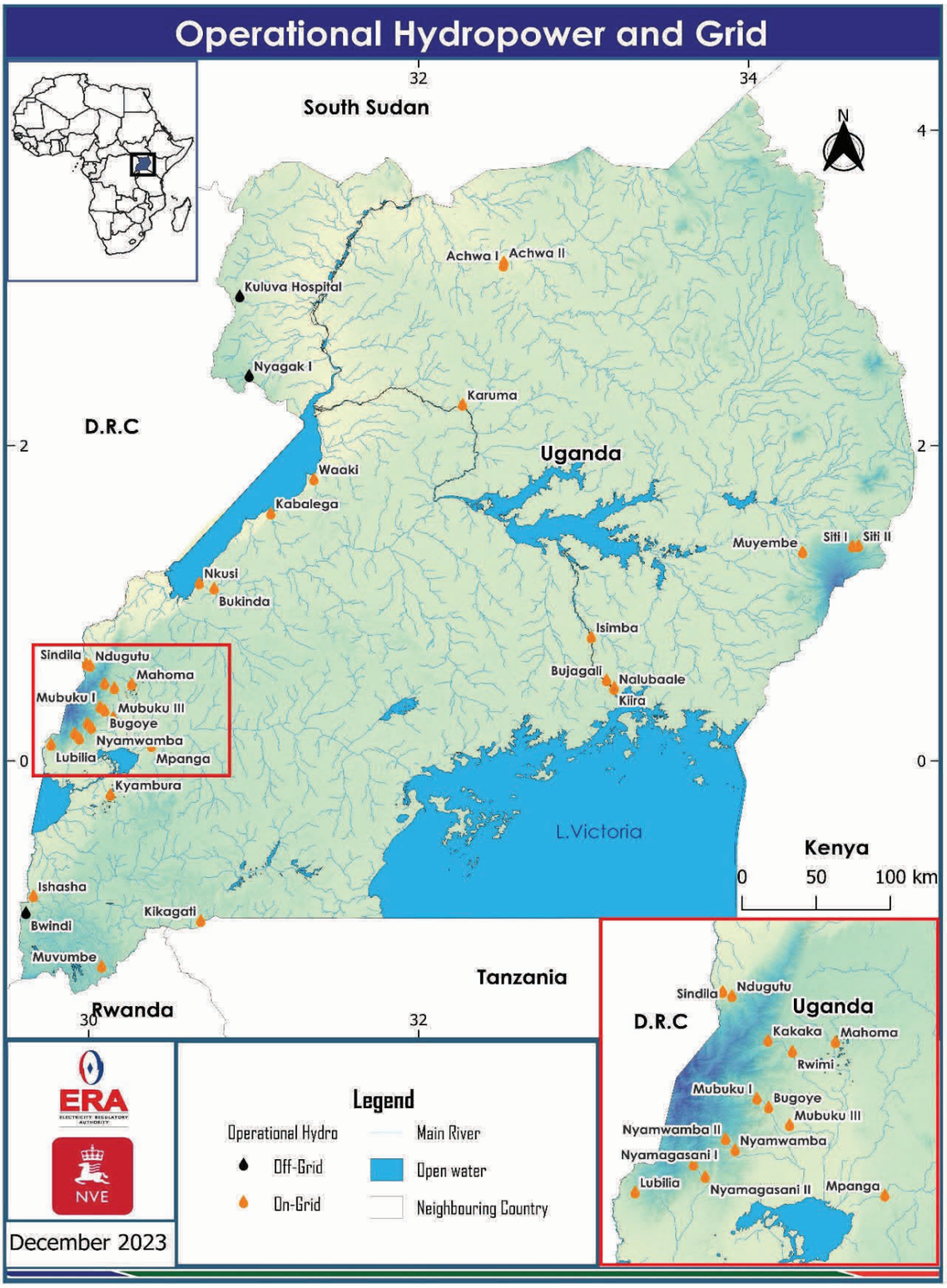


Figure 2-12: Locations of operational hydropower projects by grid connection.

There are several small hydropower projects under construction and licensed to commence construction (see Annex 3). Once these projects are commissioned, they will contribute an additional 109 MW to the national grid, hence increasing hydropower's share of the generation mix. As with the operational small hydropower projects, the majority of these are located within the Mount Rwenzori and Mount Elgon catchment areas as shown in Figure 2-13. Annex 3 also lists 14 small and mini hydropower projects that are undergoing feasibility studies.

Additional large and medium-sized hydropower projects are undergoing feasibility studies as shown in Table 2-3 with a combined tentative capacity of 1,610 MW. All the large hydropower projects undergoing feasibility studies are located along the Victoria Nile within the Murchison Falls National Park.

Table 2-3: Large and medium-scale hydropower generation sites undergoing feasibility studies.

Project name	Classification	Connection	Tentative capacity (MW)
Ayago	Large	On-grid	840
Oriang	Large	On-grid	392
Kiba	Large	On-grid	330
Muzizi	Medium	On-grid	48
Total			**1,610**

Source: ERA Database, 2023.

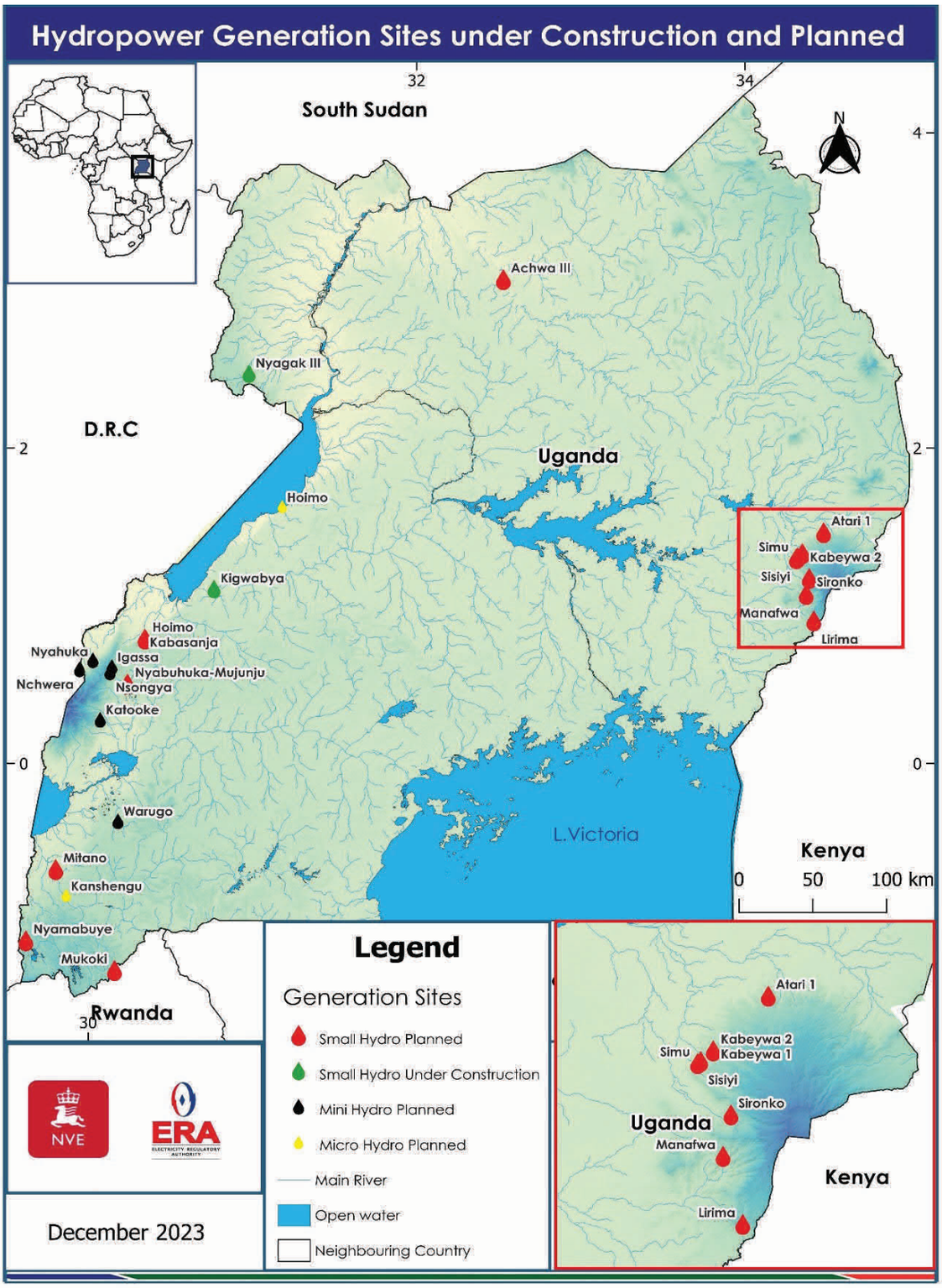


Figure 2-13: Locations of hydropower projects under construction or planned.

Typical Layouts for Hydropower Projects

Hydropower projects vary substantially in their specific characteristics but have common features that have been illustrated in Figures 2-14 to 2-16.

A dam or weir is constructed to control water flow and divert water into an intake that transports water via a waterway to a power station where the force of the water rotates turbines that turn generators such that electricity is generated before being evacuated to end users via transmission and distribution lines.

The dam or weir acting as a diversion structure varies from small weirs that are hardly visible and have no storage of water to large dams that create a reservoir storing large volumes of water. The Nalubaale dam (Owen Falls) in Jinja (see Figure 2-1 on page 16 above) is an example of a large dam while Figure 2-10 on page 45 above is an example of a weir.

The waterway for small hydropower projects in Uganda typically consists of a headrace canal leading to a forebay with a spillway (Figure 2-14), or a low-pressure pipeline or tunnel leading to a surge tower without a spillway (Figure 2-15). From the forebay or surge tower, a high-pressure pipeline called a penstock or tunnel leads the water to the powerhouse where water spins a turbine that activates a generator producing electricity. After passing through the turbines, water typically is returned to the river through a tailrace that can be an open canal, a pipeline or a tunnel. Between the dam or weir and the tailrace, the river flow is typically reduced substantially or even completely for much of the year.

Most hydropower projects in Uganda have a small weir but most of the generation capacity can be found in five projects that have large dams. The large hydropower projects in Uganda typically have the power station located near the dam (see Figure 2-16 for illustration), unlike most small hydropower projects that tend to have a longer waterway between the intake and the power station (see Figures 2-14 and 2-15).

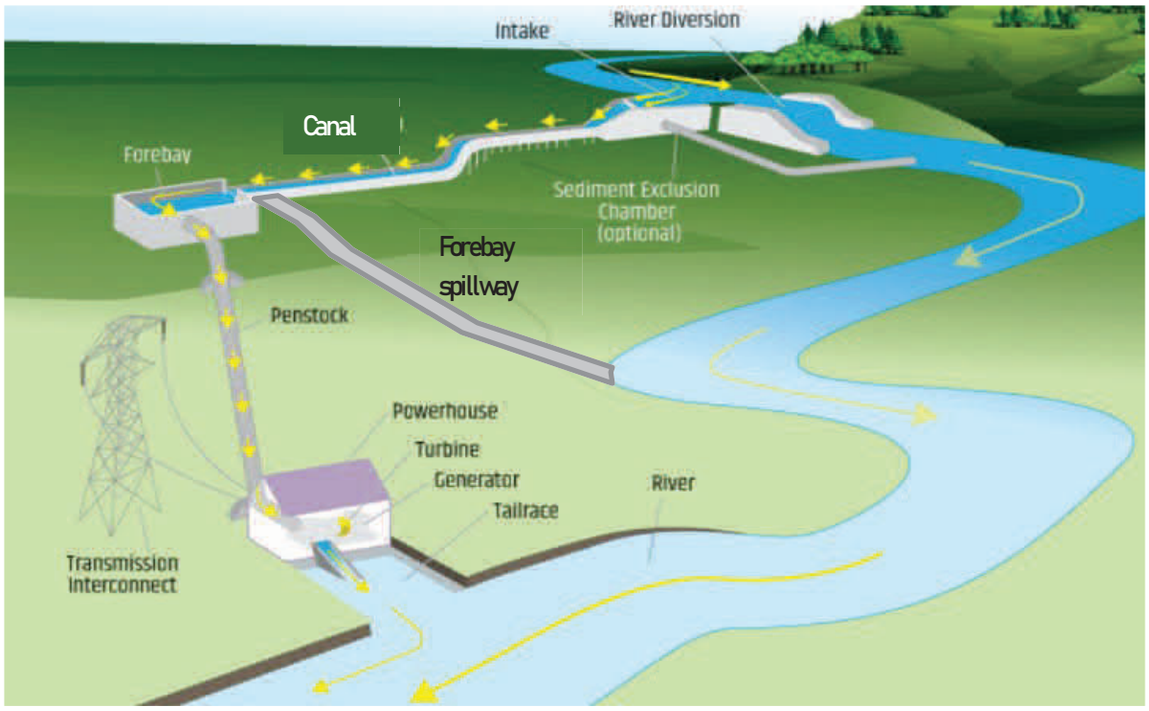


Figure 2-14: Illustration of a hydropower project with an open canal and forebay (modified from: US Department of Energy, 2024).

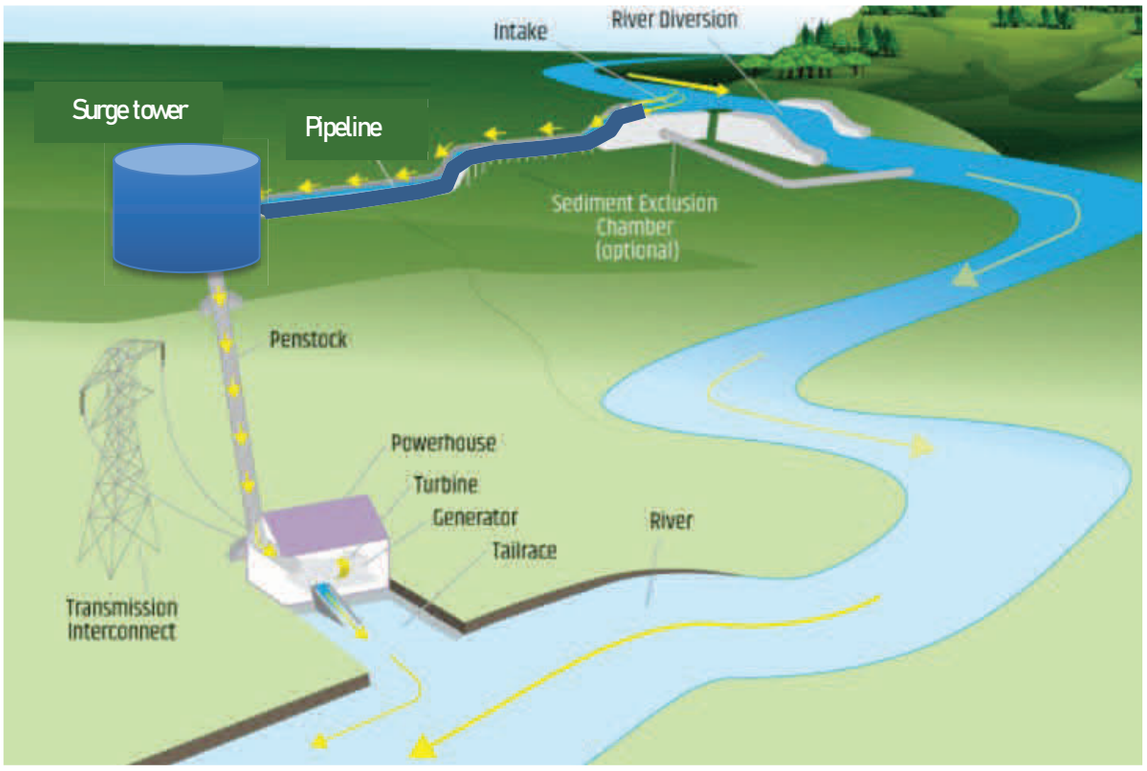


Figure 2-15: Illustration of a hydropower project with pipeline and surge tower (modified from: US Department of Energy, 2024).

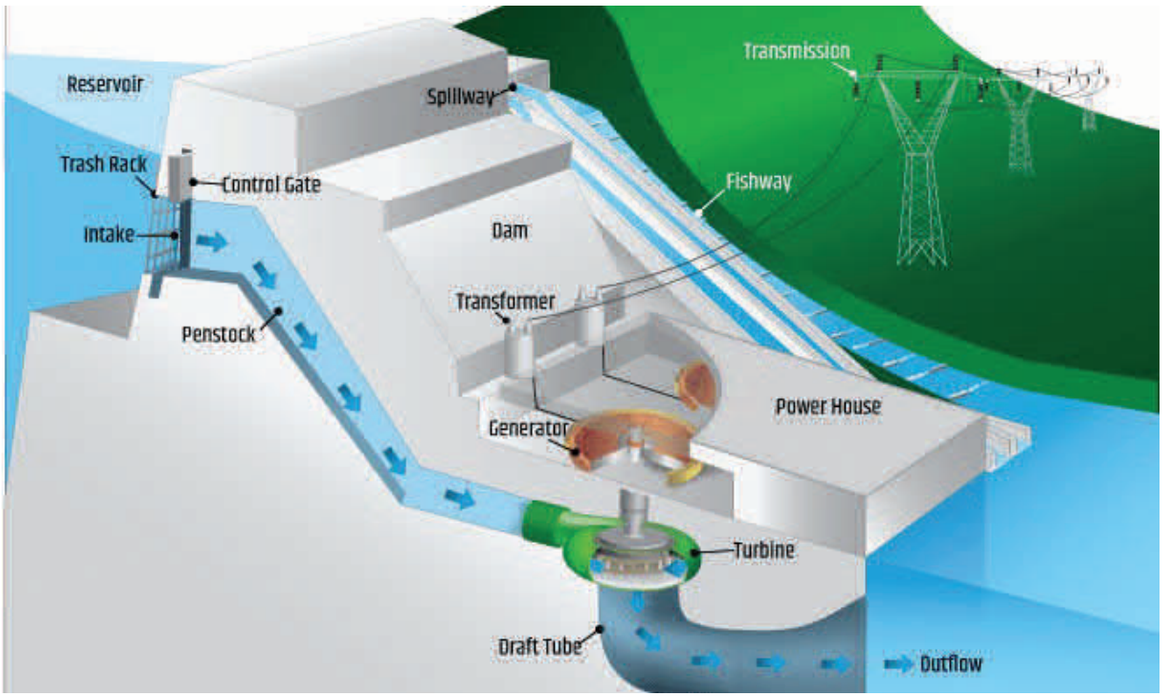


Figure 2-16: Illustration of a hydropower project with a large dam and powerhouse near the dam (modified from: US Department of Energy, 2024).

Run-of-river versus Storage

An important distinction between hydropower projects is whether these are called run-of-river projects or storage projects. A run-of-river hydropower project can be characterised by having limited or no water storage. The river flow coming into the project dam or weir equals the flow going through the project waterway and powerhouse and being returned to the river downstream of the powerhouse, including any environmental flow release at the dam or weir.

A storage project typically has a larger dam and creates a reservoir with the capacity to store a large volume of water for hours, days or longer. This results in more flexibility in how the power station is operated. Water can be stored from one period to another before being used for power generation, and the incoming flow to the reservoir can vary from the volume released downstream of the power station at any given time.

Most hydropower projects in Uganda are run-of-river without large reservoirs and with little or no alteration in the river's flow regime through storage.

Hydro-peaking

For projects with storage capacity, there is flexibility to adjust power production and hence flow downstream of the powerhouse to meet fluctuations in electricity demand. Such variation of the water flow through the turbines to match electricity demand is often referred to as hydro-peaking. Hydro-peaking can result in substantial variation in flows downstream, at times over short periods of time, and this can have substantial adverse impacts on ecosystems and water users. Very few projects in Uganda have the storage capacity to undertake hydro-peaking (see Table 4-1 on pages 107 and 108 for more information).

2.8.5 Co-generation Projects

The co-generation power projects involve the combustion of biomass to generate heat in the form of superheated steam which is used to drive a steam turbine and the exhaust heat/steam is used for other industrial processes, such as in the sugar mills and alcohol distillation (Figure 2-17). The largest co-generation power projects in Uganda are located within sugar milling complexes (Figure 2-18) and electricity generated is primarily for their own use and excess power is sold to the national grid. The fuel source for major cogeneration facilities is bagasse (dry, fibrous material that remains after crushing sugarcane stalks to extract their juice) and other biomass products such as agricultural waste.

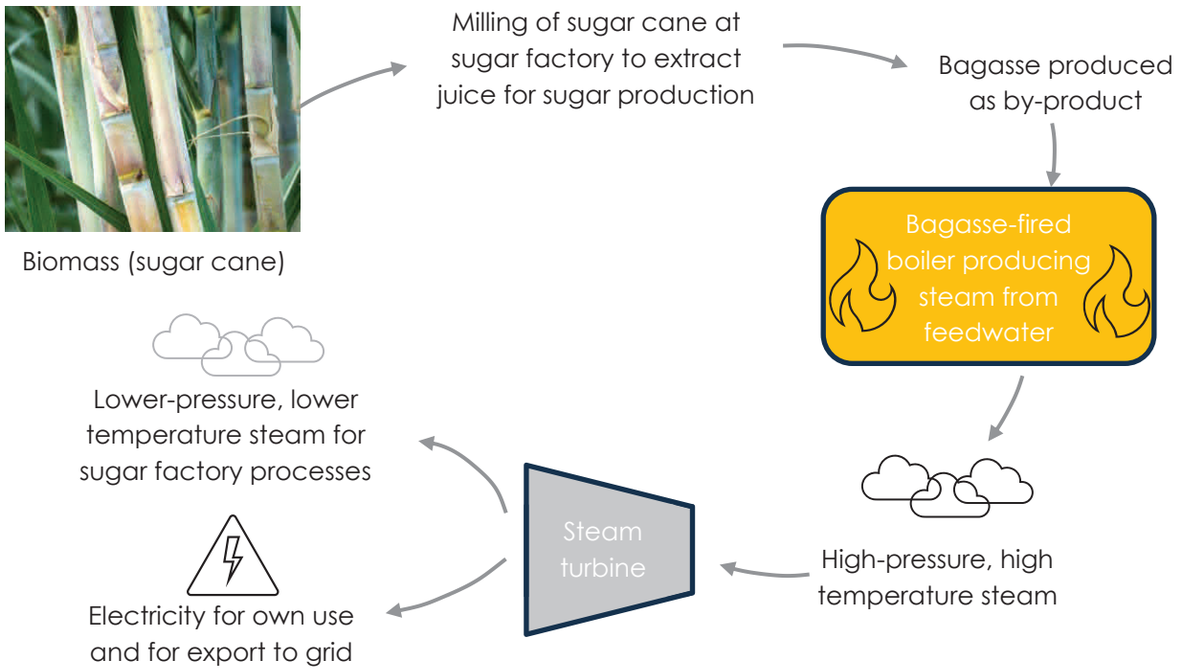


Figure 2-17: Illustration of a co-generation project producing steam and electricity from biomass (bagasse).



Figure 2-18: Bagasse-fired co-generation plant at Kakira sugar factory (photo by ERA).

As of 2023, there were eight (8) operational co-generation power generation contributing 147.85 MW to the country's combined installed capacity and 8.0% of the grid connected plants (see Table 2-4). The difference between licensed capacity and capacity sold to the grid is capacity for own use at the sugar factories. Figure 2-19 shows the locations of these projects.

Table 2-4: Operational thermal biomass electricity generation projects as of 2023.

Licensee	Commissioned (year)	Licensed capacity (MW)	Capacity sold to grid (MW)
Sugar Cooperation of Uganda Ltd. (SCOUL)	1998	26.00	15.00
Kinyara Sugar Works Ltd.	2010	14.50	1.67
Kakira Sugar Ltd.	2014	51.10	32.00
Sugar and Allied Industries Ltd.	2015	11.90	5.00
Mayuge Sugar Industries Ltd.	2015	22.00	8.00
Hoima Sugar Ltd.	2020	12.00	0.00
GM Sugar Ltd.	2021	7.35	0.00
Kamuli Sugar Ltd.	2021	3.00	0.00
Total		**147.85**	**61.67**

Source: ERA Database, 2023.

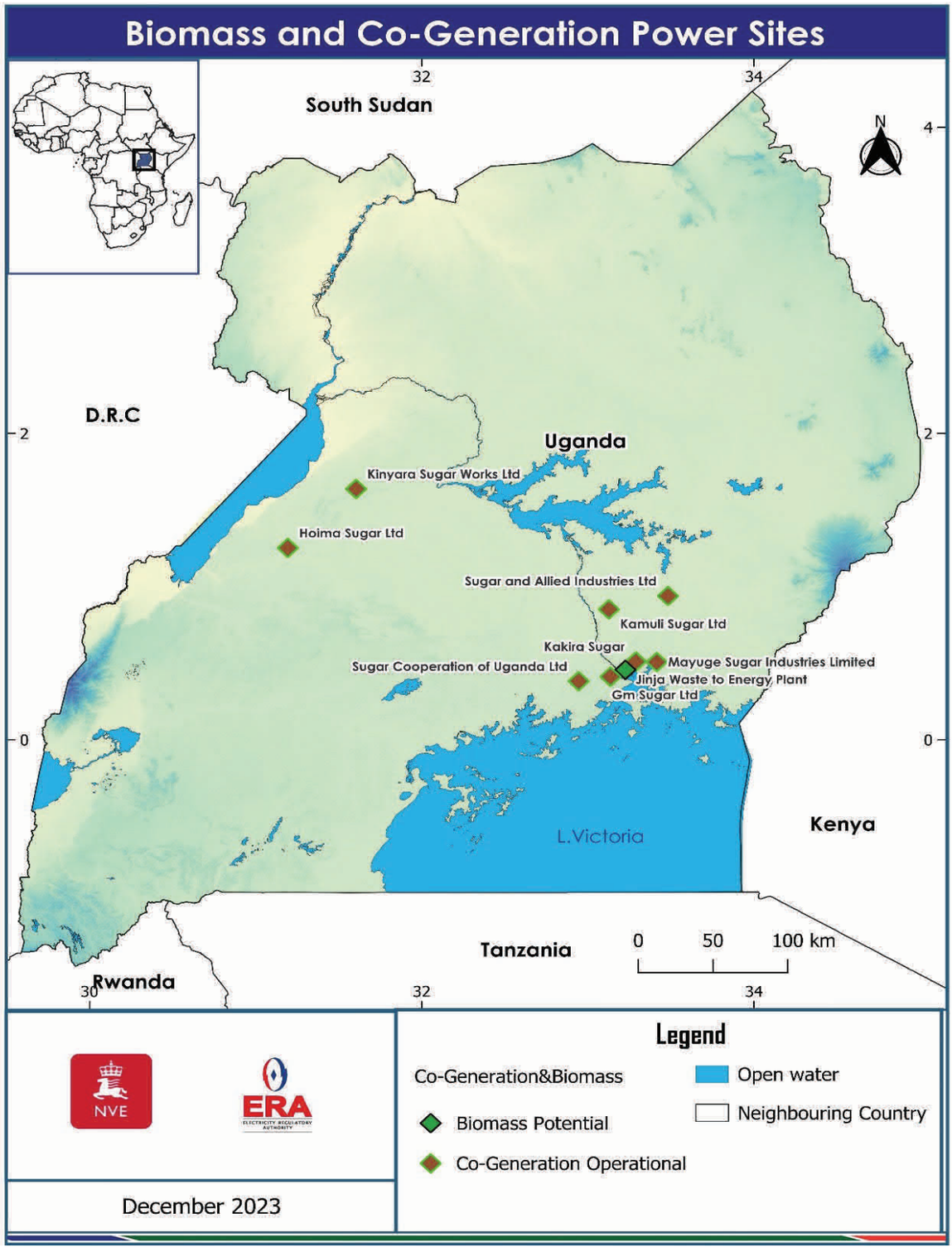


Figure 2-19: Locations of biomass-based co-generation power projects (operational, planned, and potential).

2.8.6 Thermal Power Plants (HFO)

The heavy fuel oil (HFO) power projects in Uganda contribute 100MW to the country's installed capacity thus accounting for 5.4% of the grid connected capacity. However, out of the 100 MW, 50 MW is currently on standby and the remaining 50 MW is operated only as a peaking and emergency plant. Figure 2-20 shows an example of such power plant and Figure 2-21 indicates the project locations.



Figure 2-20: Namanve thermal (fossil fuel) power plant (photo by UEGCL).

The share of grid electricity generated from HFO has significantly reduced over the past 15 years. From more than 40% in 2010 to only 1% in 2023 as shown in Figure 2-22.

In addition to HFO, the country is developing gas-to-power projects within the Albertine Graben, which after commissioning will increase the generation from non-renewable sources. These gas-to-power projects are being developed as captive projects to consume the associated gas arising for oil and gas development.

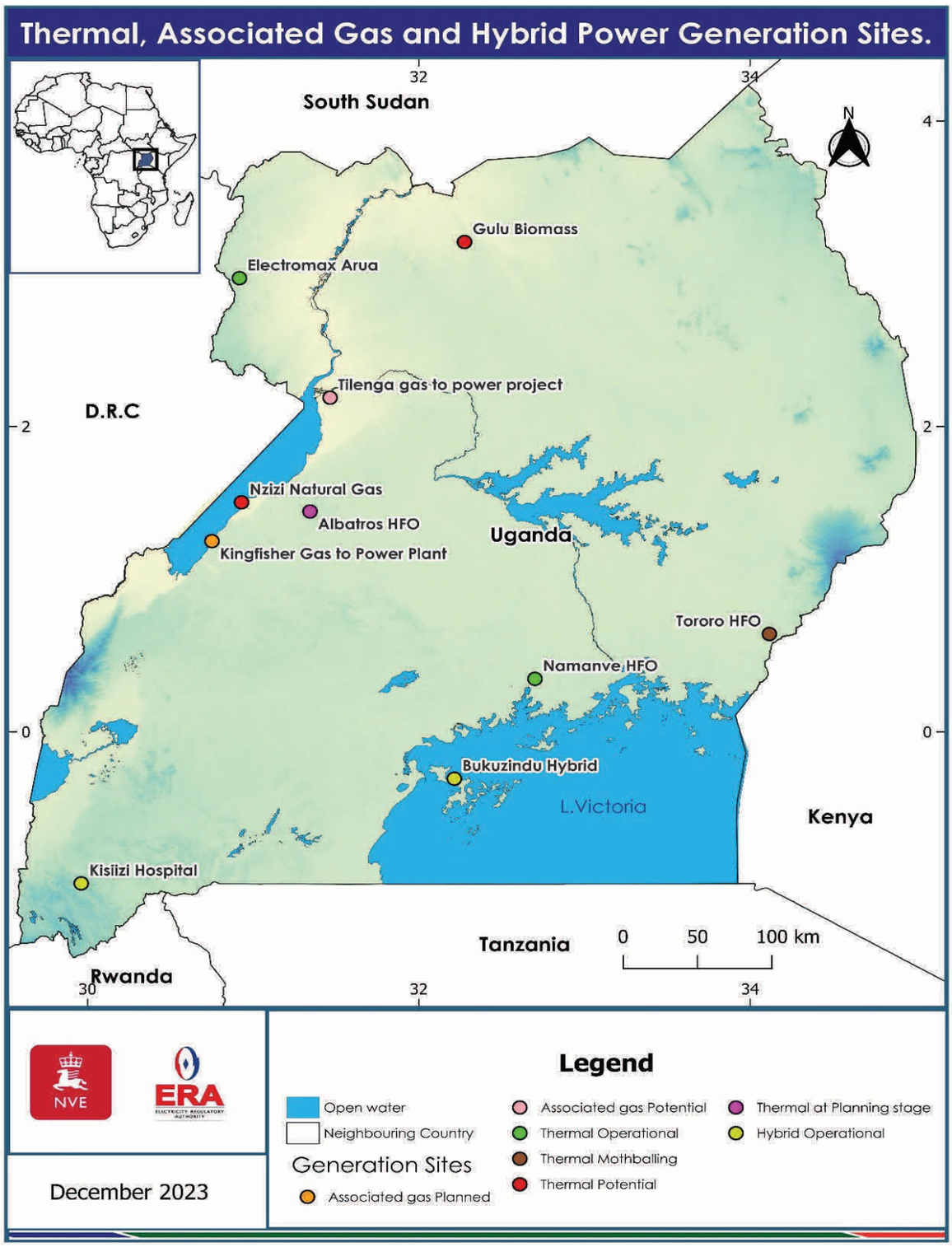


Figure 2-21: Locations of thermal, associated gas and hybrid power generation sites.

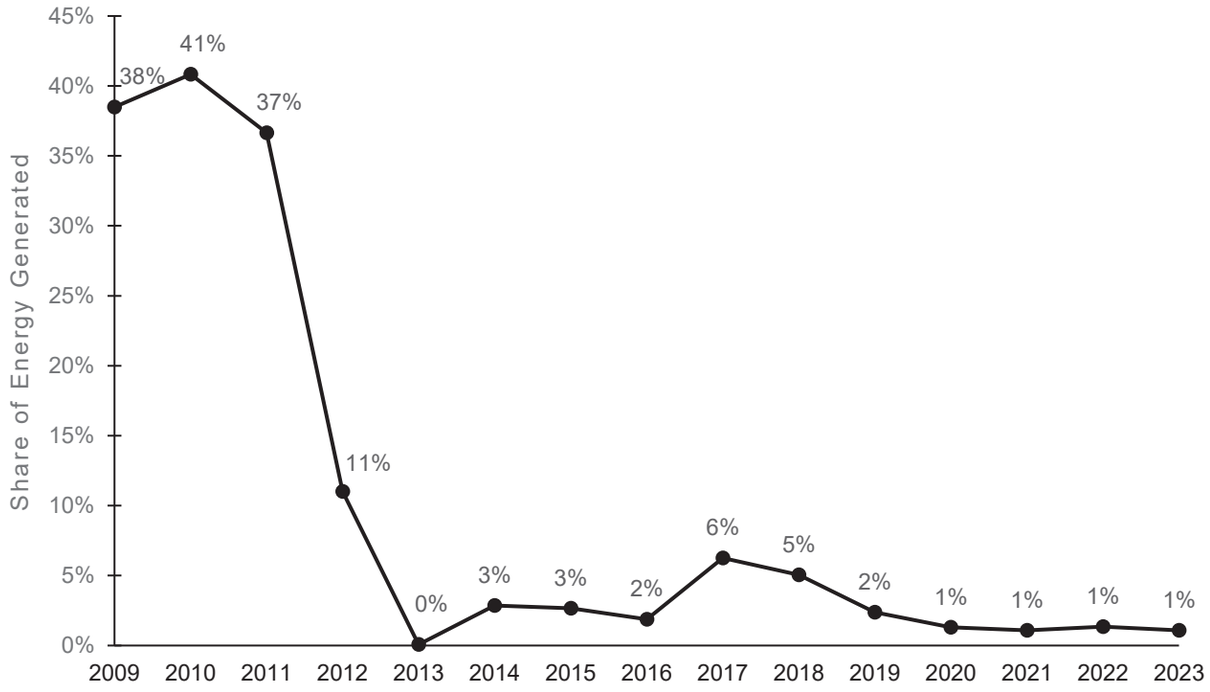


Figure 2-22: Share of electricity generated from heavy fuel oil in the period 2009-2013 (source: ERA Database, 2023).

2.8.7 Solar PV

Uganda commissioned its first grid-connected solar photovoltaic project in 2016 from a 10 MWp project in Soroti District (Figure 2-23). The amount of solar PV projects connected to the grid has increased to 84 MWp (see Table 2-5). The solar PV projects provided approximately 1.6% of generated electricity for the grid (GWh) in 2023. An additional 20 MWp of solar PV has been licensed to commence construction soon (Figure 2-24). ERA has received an application for an additional 30 MWp.

As highlighted in the 2023 Energy Policy (MEMD, 2023) and in the 2023 Energy Transition Plan for Uganda (IEA, 2023), Uganda's solar potential is very large. The potential also includes floating solar panels on water reservoirs, including hydropower reservoirs.

Table 2-5: Operational on-grid solar PV projects as of 2023.

Licensee	Licensed capacity (MWp)	Commissioned (year)	On-grid or off-grid
Access Uganda Solar Ltd.	10.0	2016	On-grid
Tororo Solar North Ltd.	10.0	2017	On-grid
MSS Xsabo Power Ltd.	20.0	2018	On-grid
Emerging Power Uganda Ltd.	10.0	2019	On-grid
Tororo PV Company Ltd.	10.0	2020	On-grid
Busitema University	4.0	2022	Off-grid
Xsabo Nkonge Solarline II Ltd.	20.0	2023	On-grid
Total	**84.0**		

Source: ERA Database, 2023.



Figure 2-23: Soroti Solar PV Plant (10 MW), the first grid-connected solar PV project in Uganda and the largest in East Africa at the time of commissioning in 2016 (photo by GET FiT Uganda).

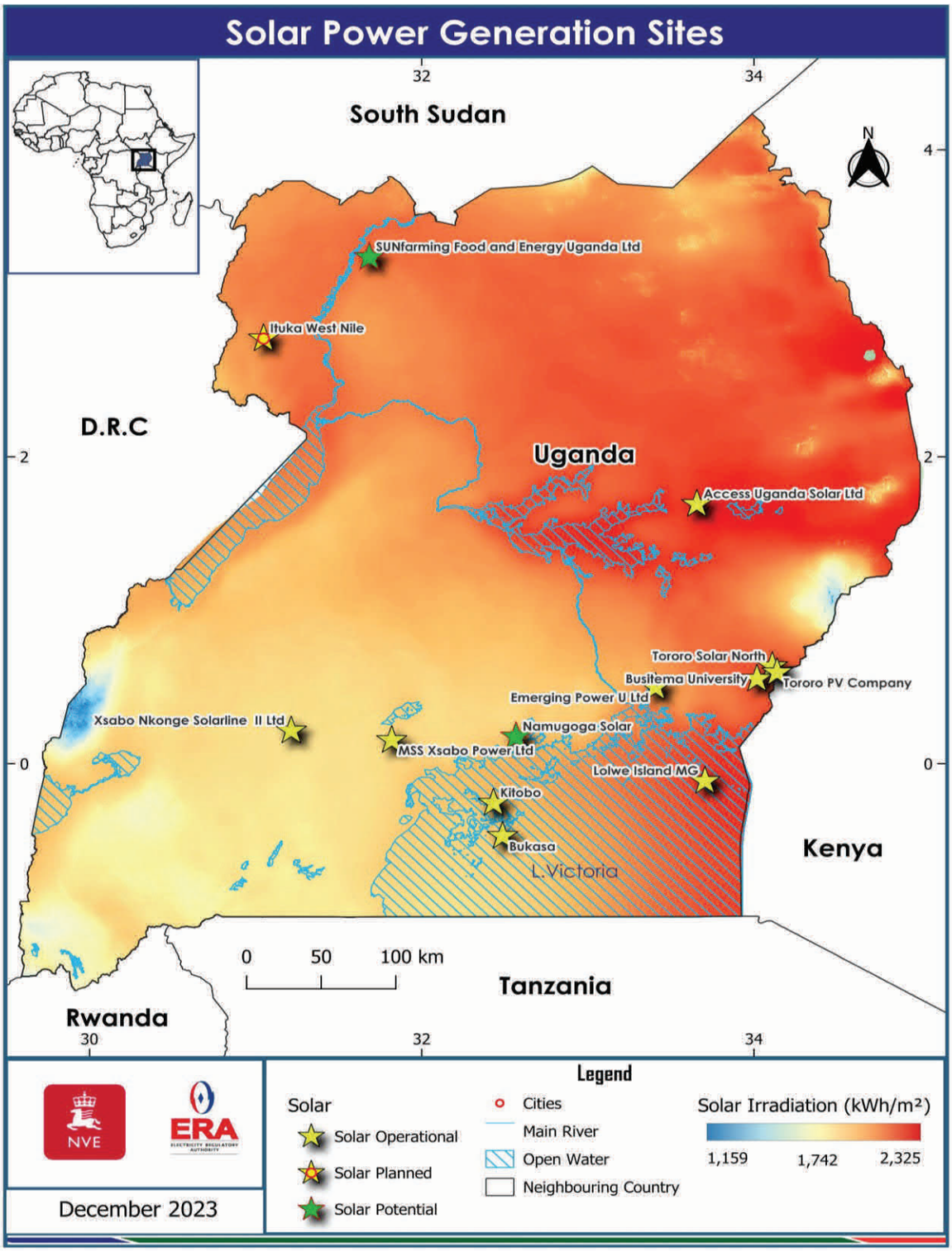


Figure 2-24: Locations of on-grid and off-grid solar PV projects (operational, planned, and potential) and solar irradiation.

2.8.8 Other Sources of Electricity Generation

Other sources of electricity generation have been under consideration in Uganda (see Table 2-6). ERA has issued licenses to develop some of these technologies but none of these sources have materialised to connect to the national grid as of 2023. and hence no further details are provided in this report.

Table 2-6: Sources of electricity generation under consideration in Uganda but not currently delivering power to the national grid.

Sources	Current status
Wind	ERA has issued a licence for generation at a 20 MW wind project in Moroto District (see Figure 2-25).
Geothermal power	Under feasibility study. ERA has issued a permit to a developer to undertake studies leading to the development of a 10MW geothermal power project in Pakwach District.
Nuclear energy	The Ministry of Energy and Mineral Development is currently undertaking studies with the aim of developing the first grid-connected nuclear energy in 2030.
Municipal waste	Under feasibility study. ERA has issued a permit to a developer to undertake studies leading to the development of a 35 MW waste-to-electricity (combined heat and power) project in Mukono District.
Other biomass (agricultural waste, biogas)	Under feasibility study. Some isolated grid developers use maize stalk, rice husk and woodchips to electricity mainly through gasification.
Peat	The Energy Policy 2023 lists peat as one of the sources for electricity generation by 2040 but representing a minor share of the energy mix (1.6%).
Coal	ERA has issued a license to a developer for a 4.3 MW captive power project in Luweero District. In this project, a combination of coal and biomass (bamboo chippings) will be used at a planned ratio of 30% to 70%, respectively.
Others	Sources like hydrogen are under consideration by developers.

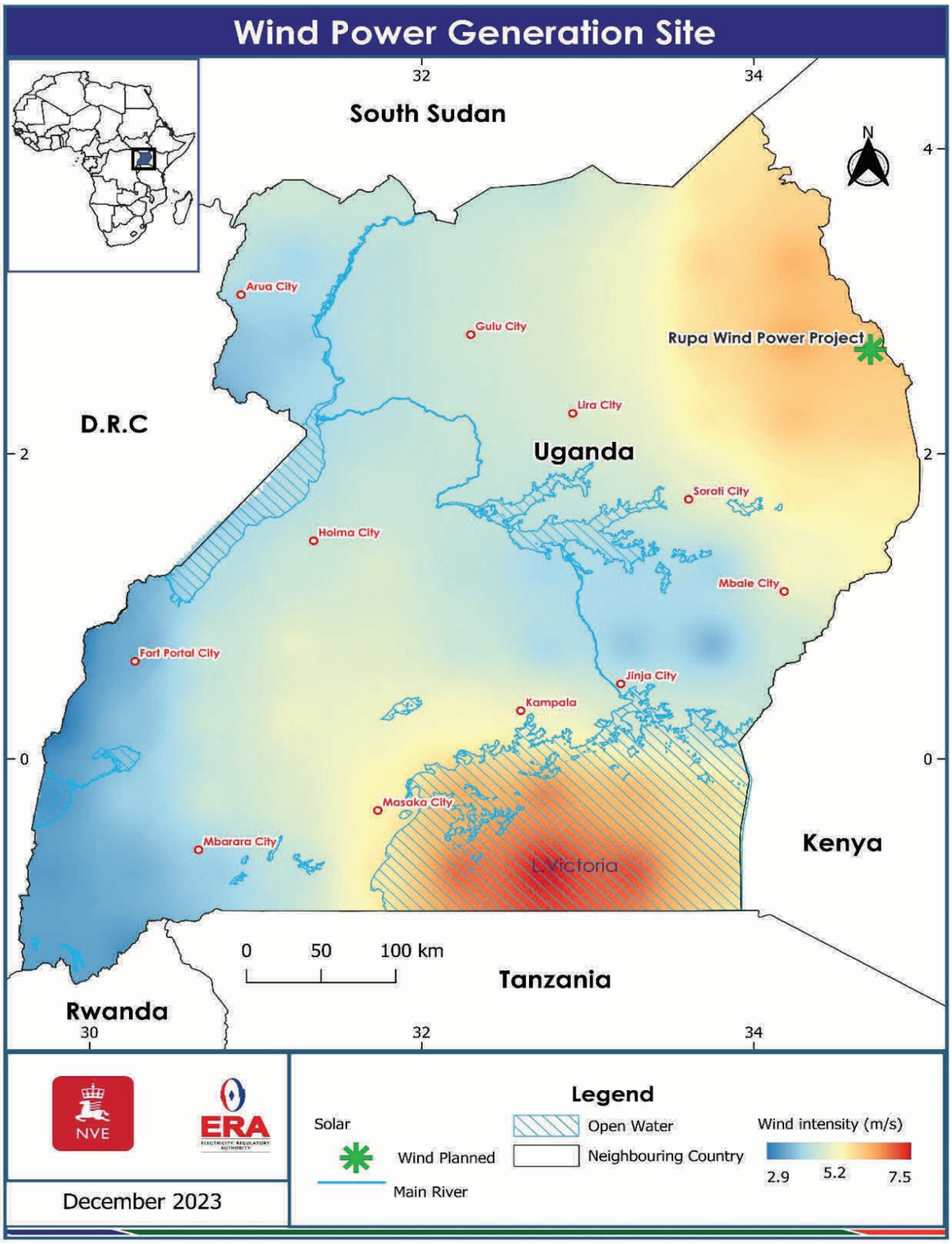


Figure 2-25: Location of a licensed wind power project and wind intensity map for Uganda.

2.9 Transmission

The electricity transmission segment comprises players who purchase power in bulk from the generation segment and transmit/evacuate the electricity either directly to customers or to the entities licensed to distribute and supply electricity to the final consumer. Currently, there is only one (1) player in the electricity transmission segment, which is the Uganda Electricity Transmission Company Limited (UETCL).

UETCL owns and operates all the transmission facilities and doubles as the system operator. As described in Section 2.3 above, the Electricity (Amendment) Act, 2022, opened the transmission segment to private sector participation and this segment is no longer limited to one bulk supplier (UETCL).

According to the Electricity Act, Cap 157, the transmission facilities include electrical circuits (transmission lines), power transformers and substations operating above a voltage of 33 kV.



Figure 2-26: The 132 kV transmission line from Achwa 1 and 2 Hydropower Plants (photo by ERA).

2.9.1 Growth and Coverage of Electricity Transmission Lines

The electricity transmission lines form the backbone of the transmission segment in Uganda. The transmission circuit length increased almost four times (288%) from 1,165 km in 2003 to 4,519km as of 2023 as shown in Figure 2-27. There are 39 substations on this network as per 2023.

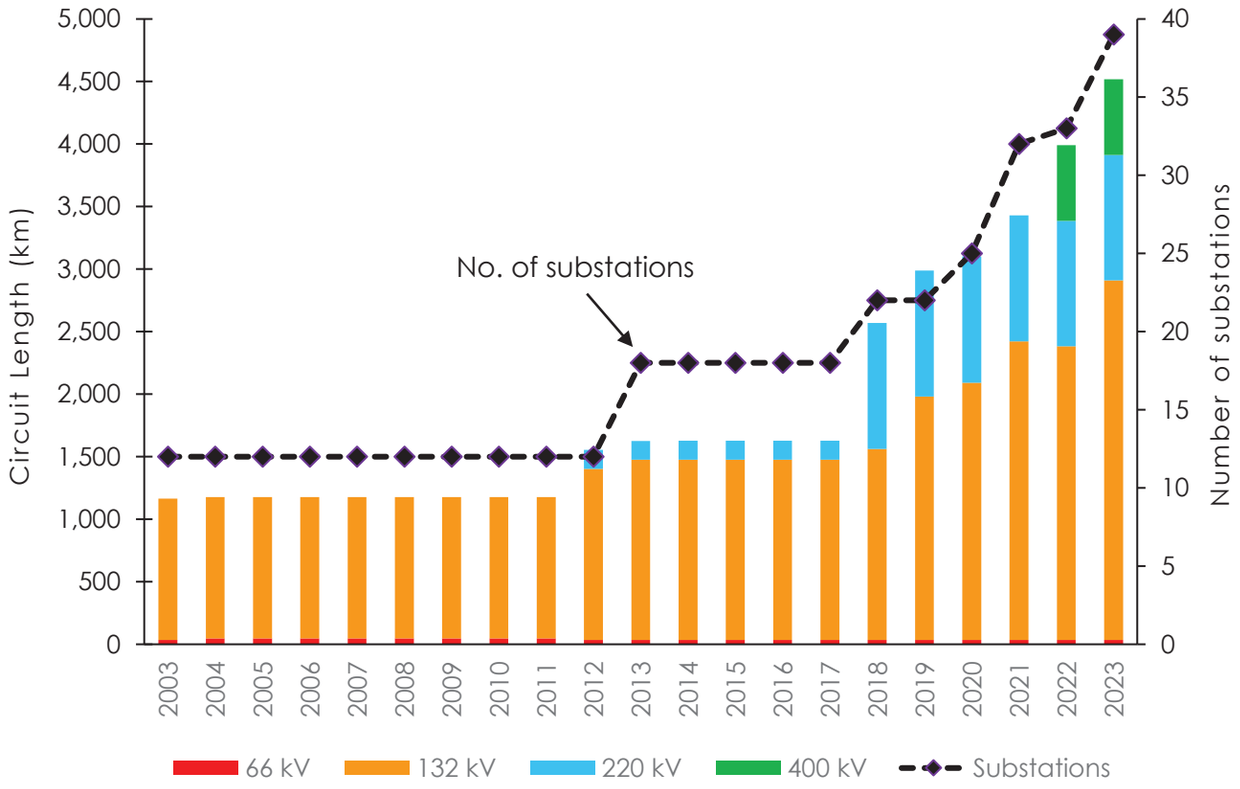


Figure 2-27: Growth is transmission circuit length from 2003 to 2023 (source: ERA Database, 2023).

The transmission line voltages in Uganda include 66 kV, 132 kV, 220 kV, and 400 kV. The circuit length for each voltage category is shown in Table 2-7 below. Most transmission lines are on steel lattices, although a few segments are on creosote-treated wooden poles and steel monopoles.

Table 2-7: Categories and corresponding circuit length as of 2023.

Voltage (kV)	Circuit length (km)	Percentage (%)
400	606	13
220	1,002	22
132	2,875	64
66	35	1
Total	**4,519**	**100**

Source: ERA Database, 2023.

All regions of Uganda are now fully integrated into the national grid as shown in Figure 2-28. There are also ongoing works to interconnect the Kalangala Islands in Lake Victoria to the national grid using 6 km of marine cables.

In addition, the transmission grid interconnects with the neighbouring countries, namely, Kenya, Tanzania, and Rwanda. Efforts to interconnect with DR Congo and South Sudan are underway.

A further 2,025 km of transmission circuits are under construction (see Figure 2-29) and 7,948 km of transmission circuits are in the planning phase (see Figure 2-30).

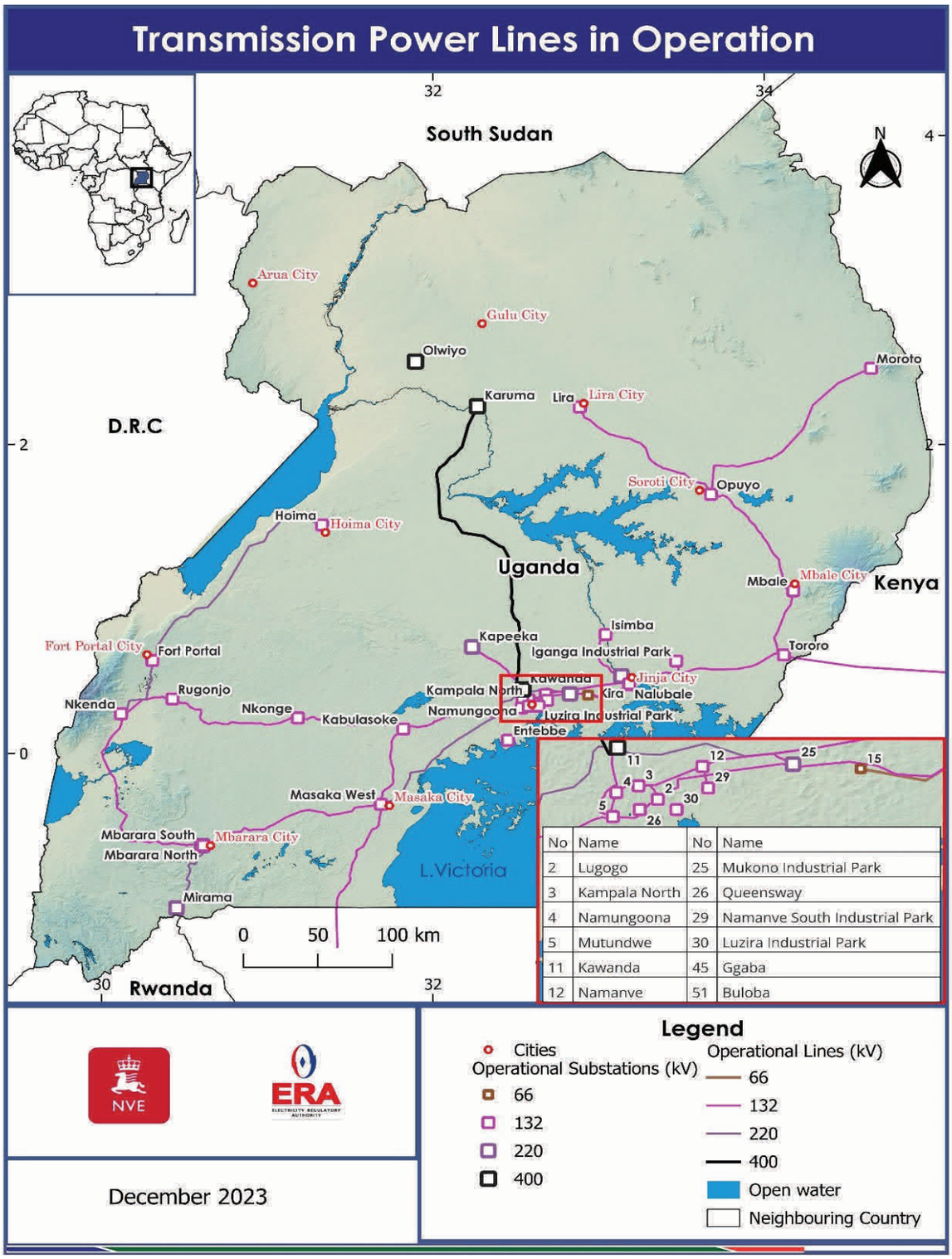


Figure 2-28: Locations of operational high voltage transmission power lines (400 kV, 220 kV, 132 kV, 66 kV) and associated substations.

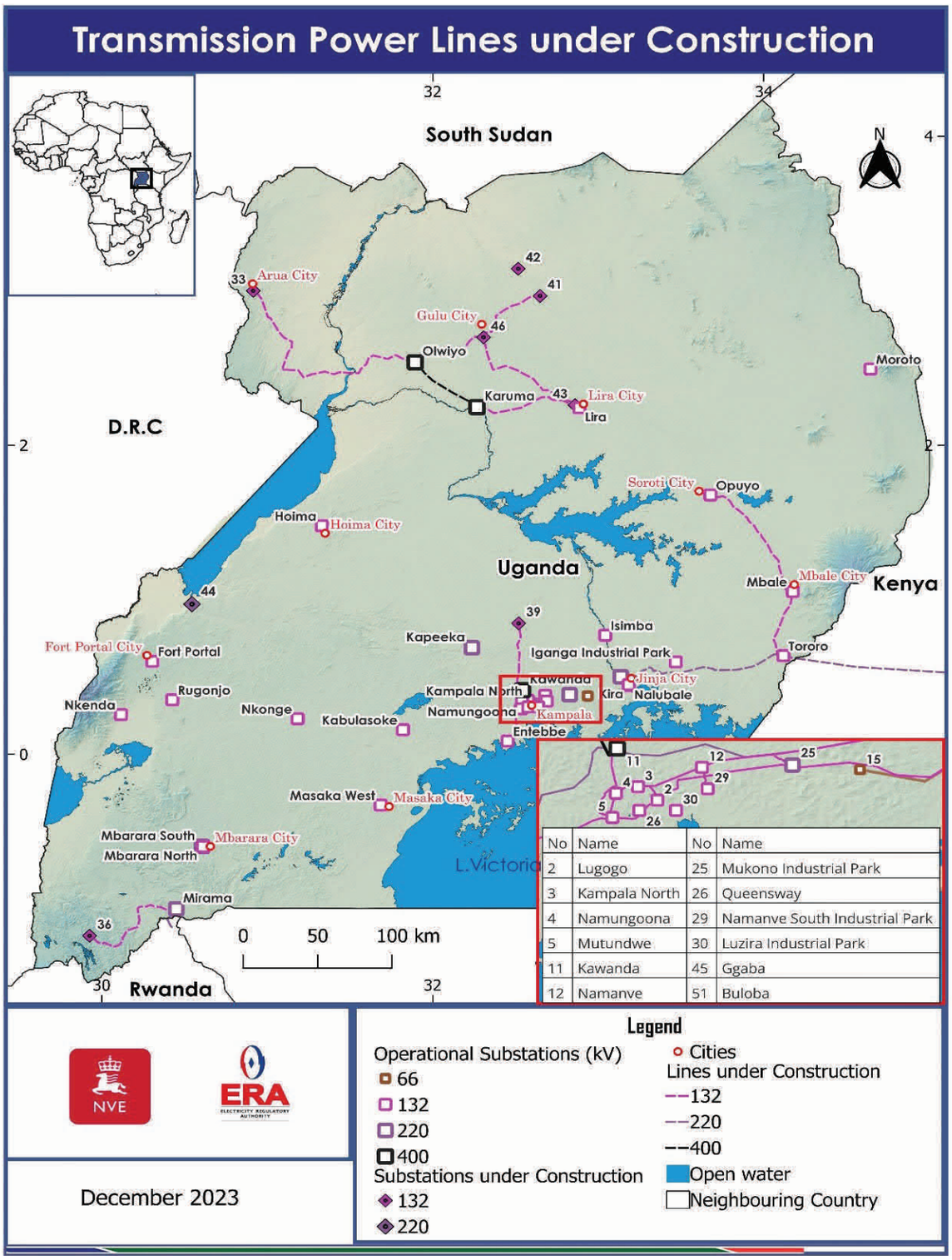


Figure 2-29: Locations of high voltage transmission power lines (400 kV, 220 kV, 132 kV) under construction and associated substations.

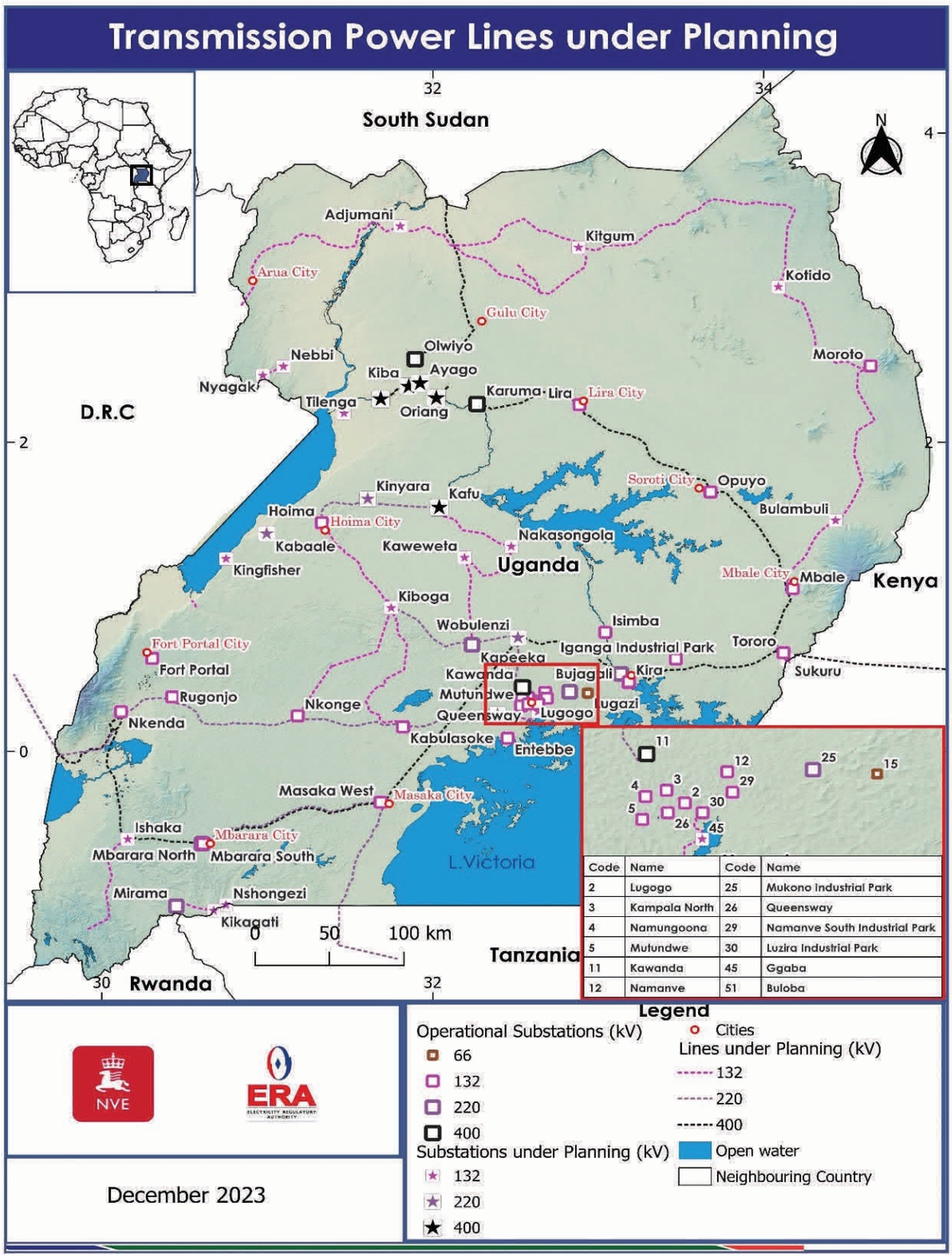


Figure 2-30: Locations of high voltage transmission power lines (400 kV, 220 kV, 132 kV) at the planning phase and associated substations.

2.9.2 Substations and Associated Installations

After the first Electricity Supply Industry reform, the UETCL inherited twelve (12) high-voltage transmission substations in 2001 from the defunct UEB. These substations were Lugogo, Kampala North, Lugazi, Tororo, Lira, Opuyo, Mbarara North, Masaka West, Nkonge, Rugonjo, Nkenda and Kabulasoke.

The number of substations increased to thirty-nine (39) operational substations in 2023 as shown in Figure 2-27 above. Additional seven (7) substations are under construction, while twenty-one (21) are in the planning phase as shown in Figures 2-29 and 2-30 above.

2.10 Distribution

As a result of a conducive electricity regulatory environment created by ERA, a remarkable improvement in the distribution of electricity in Uganda has been realised. ERA has licensed several electricity distribution operators to serve the hitherto unserved and predominantly rural communities. The number of electricity distribution companies has continued to grow from one in the year 2000 to seven at present, namely; Umeme Limited, West Nile Rural Electrification Company (WENRECo), Uganda Electricity Distribution Company Limited (UEDCL), Kyegegwa Rural Energy Co-operative Society (KRECS), Kilembe Investments Limited (KIL), Hydromax, and Kalangala Infrastructure Services Limited (KIS). These companies are operating in various regions to increase access to electricity. It is important to note that the number of distribution licensees is likely to reduce due to the government policy on the rationalisation of government entities; which may result in mergers of some of these companies.

Energy losses in the distribution segment have been reduced from over 30% at the time of liberalisation to slightly less than 17.3%. The access to clean energy has also increased with the grid-connected customer base growing from approximately 180,000 customers in 2001 to 2,107,906 in 2023, excluding off-grid customers (ERA Database, 2023). As of 2022, the rate of grid electricity access was standing at 19% and is expected to grow to 80% by 2040. The electricity grid availability at distribution stood

at 75% and is expected at 95% by 2040 by reducing downtime of the distribution grid (MEMD, 2023).

Between 2005 and 2023, Uganda's distribution network expanded almost four times, from a length of 17,256 km in 2005 to 64,516 km in 2023 (ERA Database, 2023), see Figure 2-31. The low-voltage lines (LV) dominate the distribution network. Growth in the period has mainly been in low-voltage and 33 kV lines. The growth rate was low in the period 2005-2011 and substantially higher in the period 2011-2023 (see Figure 2-31).

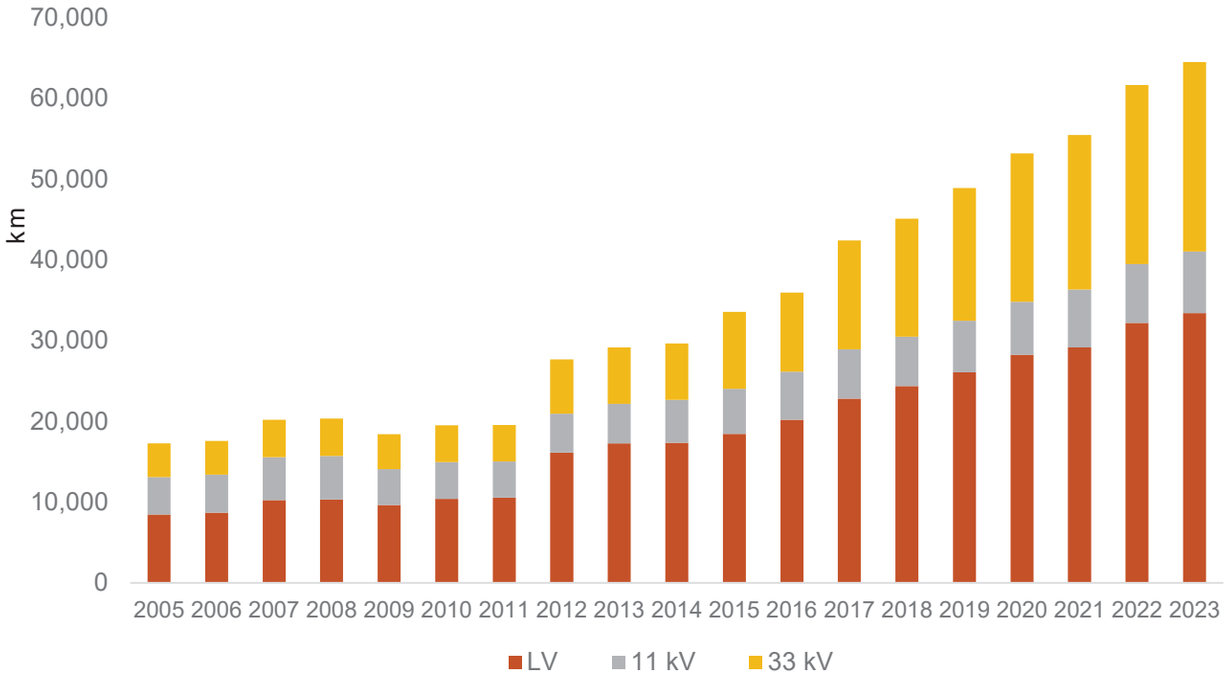


Figure 2-31: Growth in the distribution network length 2018-2023 (source: ERA Database, 2023).

2.11 Isolated Grids

The Electricity Regulatory Authority has licensed several isolated grid systems in line with the Electricity (Isolated Grid System) Regulation, 2020, to support access to electricity in rural areas not covered by the national grid. The combined installed capacity for isolated grid systems is 5.35 MW as of 2023 (see Table 2-8).

Table 2-8: Operational, isolated grid systems in Uganda as of 2023.

Name of grid	Licensee	Generation source	Licensed capacity (MW)	Commissioned (year)
Kuluva Hospital	Kuluva Hospital Mini Power Generation Company Limited	Hydro	0.12	1995
Kisiizi Hospital Power	Kisiizi Hospital Power Limited	Hydro-diesel hybrid	0.44	2009
Bwindi	Bwindi Community Micro Hydro Power Ltd	Hydro	0.06	2014
Kalangala Infrastructure Services	Kalangala Infrastructure Services Limited	Solar-diesel hybrid	1.60	2015
Kitobo off-grid	Absolute Energy Africa Limited	Solar PV	0.23	2016
Bukasa Island Off-grid	Absolute Energy Africa Limited	Solar-diesel hybrid	0.10	2020
Sagewood	Hexing - Sagewood Consortium	Solar-diesel hybrid	0.17	2021
Lolwe	Engie Equatorial	Solar PV	0.55	2022
Bunjanko	Winch Energy Uganda SMC Ltd	Solar PV	0.12	2022
Lamwo off-grids	Winch Energy Uganda SMC Ltd	Solar PV	1.00	2022
Got Ngur	Mandulis Energy Ltd	Solar-biomass hybrid	0.44	2022
Volt-Terra	Volt-Terra Farm and Energy Solutions Limited	Solar PV	0.06	2022
Katiirwa	Kyegegwa Rural Electricity Cooperative Society Limited	Solar-diesel hybrid	0.056	2022
Bussi	Solargen (U) Limited	Solar PV	0.40	2023
Total			**5.35**	

Source: ERA Database, 2023.

As indicated in Table 2-8 above, half of the 14 isolated grid systems use hybrid energy sources, which include a combination of solar PV, battery energy storage system, hydropower, diesel generators and sometimes biomass gasification to generate electricity. Six of the isolated grids are based on solar PV and one uses a mini hydropower project.

Each of the isolated grid systems comprises a power generation source (or hybrid), short distribution lines and customer interconnections. In most cases, the distribution line is less than 15 km.



Figure 2-32: The Got Ngur off-grid generation facility combining solar PV and biomass (0.44 MW) commissioned in 2022 (photo by ERA).

2.12 References

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ENVIRONMENTAL ISSUES IN THE ELECTRICITY SUPPLY INDUSTRY



Sediment flushing from the dam of one of the hydropower projects in Uganda (photo by Ziba Limited).

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ENVIRONMENTAL ISSUES IN THE ELECTRICITY SUPPLY INDUSTRY



3 ENVIRONMENTAL ISSUES IN THE ELECTRICITY SUPPLY INDUSTRY

3.1 Driver and Pressures of Environmental Change

3.1.1 Driver

In the Driver-Pressure-State-Impact-Response (DPSIR) framework, the underlying driver is typically a socio-economic need or force that results into pressures on the environment. For the Electricity Supply Industry, the main driver of environmental change is an increasing societal need for energy in the form of electricity (see Section 2.8 above).

The Energy Policy 2023 estimated that Uganda will require approximately 52,000 MW by 2040, representing an increase in electricity consumption per capita to 3,668 kWh. The access to the national grid must significantly increase to 80 per cent (MEMD, 2023). The need for electricity results in pressures and/or actions to develop electricity infrastructure, such as, generation projects and associated transmission and distribution networks to transport the power and connect end users of the electricity. These pressures are discussed in Section 3.1.2 with further details in Sections 4 to 9 below.

3.1.2 Pressure

In the DPSIR framework, the pressures resulting from the driver are typically direct forces on the environment such as land take, resource extraction or pollutant releases. For households, institutions and industries to access electricity, there is a chain of activities that need to be undertaken and that results in such pressures on the environment. These include:

- Generation: Electricity needs to be generated and this can be from; hydropower, fossil fuel-based thermal power, biomass-based thermal power, solar PV, or other sources.

- Transmission: Electricity needs to be evacuated from the generation facilities over considerable distances to reach different load centres in different parts of the country. High-voltage transmission lines (400 kV, 220 kV, 132 kV, and 66 kV) are used for this purpose, as these lines are more efficient in evacuating electricity over long distances compared to medium or low-voltage lines.
- Distribution: For the end user (consumer) to access electricity on the grid, a large network of smaller power lines of medium (33 kV, and 11 kV) or low voltage (< 11 kV) are developed to connect millions of users.
- Substations: Substations are installations for transformation of electricity associated with the above-listed infrastructure.
- Isolated grids: In areas beyond the reach of the national grid, smaller facilities in the form of isolated grids are constructed to generate as well as transport power to the end user.

The main pressures on the environment from the Electricity Supply Industry are the infrastructure associated with the generation, transmission and distribution of electricity as part of the national grid. This is illustrated in Figure 3-1.

Pressures on the environment due to a potentially substantial number of emerging mini-grids based on solar PV are not specifically discussed in this ESISOER due to limited data available on the environmental impacts related to such mini-grids in Uganda. While the environmental impacts of these small-scale projects are typically limited, such electricity infrastructure will be considered in future updates of the ESISOER, as more data and experiences from such developments become available.

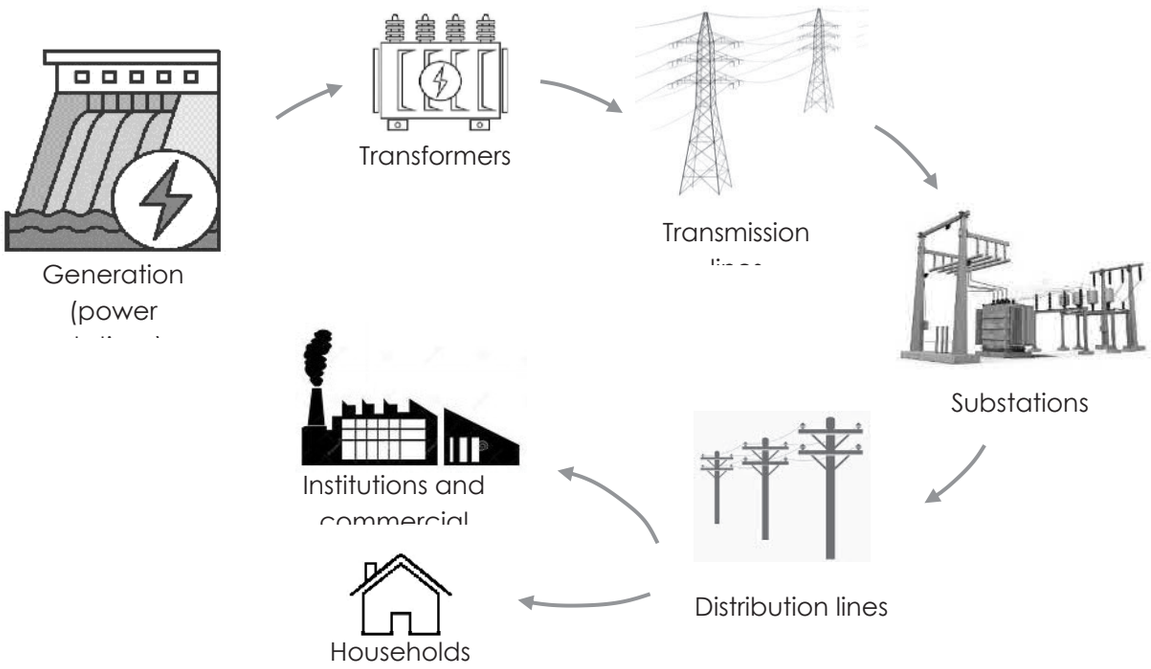


Figure 3-1: Illustration of a typical layout for a national grid including generation sources, transmission facilities, and distribution facilities to the end consumers.

The electricity demand will increase substantially in the coming years, and this will result in increasing pressures on the environment. The nature and magnitude of the actions undertaken will vary depending on the source of electricity generation to be developed and the extent and ways in which the electricity grid is expanded.

Important actions from the Electricity Supply Industry that represent pressures include:

- Water abstraction for hydropower generation.
- Land take required by all electrical installations and projects.
- Earthworks to excavate or rearrange the terrain for the purpose of electrical installations to be developed.
- Effluent releases or pollution risks for water resources from a range of activities in the sector, including hazardous and non-hazardous wastes, noise, and vibration.
- Health and safety risks for workers and local community members due to electrical infrastructure.

The above-listed actions cause varying level of change in the environmental conditions, referred to in this report as intensity. Intensity refers to the level of pressure and extent of change in environmental conditions typically occurring. For example, "high intensity" indicates that the pressure is typically substantial and may result in extensive change in the environmental conditions.

Table 3-1 summarises typical levels of pressure intensity on the environment different types of Electricity Supply Industry projects. It should be noted that there can be substantial variation in the intensity of pressures from one project to another project of the same kind, depending on the specific project design and site-specific conditions. The level of intensity indicated in Table 3-1 should therefore be considered a typical situation but will not reflect all project-specific variations. Intensity refers to the level of pressure and extent of change in environmental conditions typically occurring. For example, "high intensity" indicates that the pressure is typically substantial and may result in extensive change in the state of the environment.

Table 3-1: Typical levels of intensity for some of the main pressures from Electricity Supply Industry projects (note: there may be project-specific variation deviating from the typical intensity).

Pressures	Generation				Transmission	Distribution
	Hydro-power	Solar PV	Co-gen. (CHP)	HFO, diesel		
Water abstraction						
Effluents to water						
Land take						
Health and safety risks						
Emissions and waste						

High intensity Medium intensity Low intensity

Tables 3-2 to 3-5 below summarise some of the typical implications and characteristics of Electricity Supply Industry projects for the main pressures and their intensities outlined in Table 3-1 above. Sections 4 to 8 below provide further details on these pressures:

- Water abstraction and effluents to water are summarised in Table 3-2 and detailed further in Section 4 (Water Resources) below.
- Land take is summarised in Table 3-3 and detailed further in Section 5 (Biodiversity) and Section 6 (Social Environment).
- Health and safety risks are summarised in Table 3-4 and detailed further in Section 7 (Health and Safety).
- Emissions and waste are summarised in Table 3-5 and detailed further in Section 8 (Waste and Pollution).

Table 3-2: Typical implications of water abstraction and effluents to water associated with different types of Electricity Supply Industry projects.

Project type	Typical implications of water abstraction and water pollution
Hydropower (medium to low intensity)	All hydropower projects in Uganda abstract water from a river or an impoundment on a river. Water is led away from the river to the power station before being returned to the river. The distance of a river with reduced flow due to this abstraction varies substantially (see Section 4) and will affect water users and ecosystems (IFC, 2018). Where the power station and tailrace are integrated into, or located very near, the dam structure (e.g., Nalubaale, Kiira, Bujagali, Isimba, Kikagati), the diverted river section is short. In other instances, the distance between the abstraction point (dam, or weir) and where water is returned (tailrace) can be several km. The longest diverted river section for a single project at present is the Karuma hydropower project (11 km). Hydropower projects in Uganda return all the water to the river (non-consumptive use) but along the diverted river section, most of the water will be removed as it passes through the project waterway (canal, pipeline, or tunnel). Effluents and uncontrolled runoff into water can result in pollution (see Section 4). From hydropower projects, the level of effluents is typically low assuming hazardous materials and waste are handled appropriately and erosion and sedimentation are controlled. During construction, there will inevitably be some erosion and sedimentation caused by earth-moving activities. During project operation, any pollutant released along the diverted river section that experiences reduced flow may cause higher concentrations of pollutants (due to reduced dilution following river diversion). Removal of accumulated sediments from reservoirs (sediment flushing) can represent an important pressure in some projects.
Solar PV (low intensity)	Solar PV projects typically require a moderate to small amount of water for cleaning, if the solar panels are cleaned using water. Water pollution risks are generally low for solar PV projects.
Co-generation (medium intensity)	Co-generation projects (combined heat and power projects) typically require a small amount of water, partly for the steam cycle to transport energy in the form of heat from the co-generation plant to the end-use location for steam as well as water for regularly cleaning the co-generation plant including the boilers. Water pollution risks are generally low for a co-generation plant assuming water used for cleaning the power plant is adequately treated. The bagasse supply originates from the sugar factory in the Ugandan context, and this supply chain represents a substantially larger source of effluents and potential water pollution. The substantial volumes of

Project type	Typical implications of water abstraction and water pollution
	effluent from the sugar factories require a well-functioning effluent treatment plant to avoid serious pollution. The effluent treatment plants to treat wastewater from the sugar factories are not considered in any detail in this report.
HFO, diesel (low intensity)	Thermal power plants running on heavy fuel oil (HFO) or diesel require regular cleaning with moderate volumes of water as part of operations and maintenance. The moderate volumes of wastewater require appropriate treatment but the pressure on water resources is overall low.
Transmission (low intensity)	There is no significant water use required for high-voltage transmission lines. Water pollution risks are small and typically concerned with temporary construction activities that involve minor earth-moving activities causing erosion and sedimentation as well as potential oil or diesel spills from construction machinery and vehicles. Substations with oil-filled transformers require containment of any leakage but overall represent a low and only localised risk.
Distribution (low intensity)	The distribution lines cover larger areas than transmission lines but the risk to water resources is overall considered low and localised as for the transmission lines.

Table 3-3: Typical implications for land take associated with different types of Electricity Supply Industry projects.

Project type	Typical implications for land take
Hydropower (medium intensity)	Hydropower projects require land for the dam/weir, the reservoir (if applicable), the waterway (canal, forebay/surge tank, pipeline, or tunnel resulting in waste rock disposal), power station, tailrace and associated infrastructure such as roads, camps, and construction material source areas. The size of the reservoir (if any) and length of the waterway tend to affect land take substantially and therefore also result in displacement of people and loss of livelihoods (see Section 6) as well as biodiversity loss on land and in rivers (see Section 5). Land take and resulting displacement and biodiversity loss vary substantially from project to project and are not necessarily related to the amount of electricity generated by the hydropower project. There is large variation between projects in land take per GWh produced.
Solar PV (medium to low intensity)	Land take for solar PV projects is also significant but generally much more correlated with the installed generation capacity, that is, increasing land take with increasing installed capacity (number of solar panels). Solar irradiation is spread relatively evenly across large areas as opposed to the hydropower resource (water and drop in elevation)

Project type	Typical implications for land take
	that is typically very localised. Therefore, solar PV projects are more flexible in terms of their location, and it is easier to avoid areas with people, settlements and agriculture as well as high-value biodiversity areas.
Co-generation (low intensity)	Land take for co-generation projects is typically small for the power plant itself, which in Uganda is typically inside a sugar factory complex and therefore, does not add much pressure to the sugar factory itself. These plants are typically fuelled with bagasse residue from sugar refining. The source of the bagasse, which is sugar cane, is grown over large areas and requires large tracts of land. The characterisation of land take as a pressure of "low" intensity assumes that bagasse is a by-product or waste from sugar refining. If the land areas under sugar cane growing are considered, then the pressure can be considered as "high".
HFO, diesel (low intensity)	Land take and resulting displacement and biodiversity loss from thermal power plants running on heavy fuel oil (HFO) or diesel are low as only a small area is required and there is flexibility in locating the facility and thereby reducing resulting displacement and biodiversity loss.
Transmission (high intensity)	High voltage transmission lines typically require substantial land as the wayleave corridor can run for long distances and land is acquired with resulting displacement of people (WBG, 2007). The land requirement varies substantially between transmission lines as the width of the wayleave corridor varies with voltage: 400 kV (60 m), 220 kV (40 m), 132 kV (30 m), and 66 kV (15 m). In terms of overall land take, transmission lines are the main pressure from the Electricity Supply Industry and can result in substantial displacement and biodiversity loss. Transmission lines through protected areas and forests not only result in land take but can also open up forests and result in fragmentation of habitats and represent risks to birds that may collide with the lines or be electrocuted.
Distribution (medium intensity)	Medium and low voltage distribution lines require substantially less land as the wayleave corridor requirements are much smaller and land is typically not acquired but consent from landowners is sought, preferably in writing. Compensation for crops in the wayleave corridor is typically for a 10 m wide corridor for medium voltage lines (5 m + 5 m) and 6 m for low voltage lines (3 m + 3 m). On consent and erection of the poles of these lines, there are certain restrictions on the land use in the wayleave corridor such as limiting the tall growth plants and trees as well as not constructing structures. Even if the distribution lines overall cover longer distances than the transmission lines, the resultant pressure on the environment is typically

Project type	Typical implications for land take
	lower, because the environment is already impacted by other developments such as roads and housing. All major substations in the distribution network require land acquisition.

Table 3-4: Typical implications of health and safety risks associated with different types of Electricity Supply Industry projects.

Project type	Typical implications for health and safety risks
Hydropower (medium intensity)	Hydropower projects typically involve a wide variety of work operations during a relatively long construction phase that expose workers and surrounding community members to risks (IFC, 2018). High-risk construction activities include work at height, work in and near a river or water body, tunnel works and rock blasting. Installation of penstock pipes in steep terrain can also be high risk. Community members may be subject to comprehensive construction traffic due to a large workforce and large volumes of construction materials and equipment. There are fewer work operations during the operations and maintenance phase, but some of the facilities represent substantial risks to workers and to community members in the vicinity. For instance, the presence of open headrace canals and reservoirs represent drowning risks, high-pressure water in pipelines (penstocks) represent risks in the unlikely event of a rupture, electrical equipment can cause electrocution, and sudden releases of water from the dam or the power station/tailrace can represent drowning risks.
Solar PV (medium to low intensity)	Construction of solar PV projects involve fewer work operations, shorter construction period and less high-risk work operations. Construction traffic is a typical risk. During operations and maintenance, the likelihood of electrocution from contact with electrical facilities is a risk.
Co-generation (low intensity)	Co-generation projects typically involve a wide variety of work operations during the construction phase that expose workers to risks, for instance work at height. Co-generation projects in Uganda are typically within a fenced sugar factory facility and hence represent lower risks to surrounding communities. Community members may, however, be subject to risks related to construction traffic and the presence of a construction workforce. There are fewer work operations during the operations and maintenance phase, but some of the facilities represent risks to workers, for instance, the boilers with high noise and temperature, the high pressure-high temperature steam pipe networks, the handling of biomass fuel, and electrical equipment with electrocution risks.

Project type	Typical implications for health and safety risks
HFO, diesel (low intensity)	Health and safety risks are similar to the risks of co-generation plants. The installed infrastructure and fuel feeding operations tend to be simpler, but the fuel is a hazardous material that requires additional measures.
Transmission (high intensity)	High-voltage transmission lines represent electrocution risks. The substantial network of high voltage lines requires operation and maintenance activities that at times result in fatalities and serious injuries for workers, either during activities at the transmission lines or during transportation to/from the facilities (road accidents).
Distribution (medium intensity)	Medium and low voltage distribution lines also represent electrocution risks. The large network of distribution lines is typically concentrated in densely populated areas and interface with communities resulting in more health and safety risks than for transmission lines. Injuries and fatalities are unfortunately common when people try to connect illegally to power lines or to steal materials. There are also accidents involving operators (workers) on the grid, both during work on the line and during transport to/from the facilities (road accidents).

Table 3-5: Typical implications of emissions and waste associated with different types of Electricity Supply Industry projects.

Project type	Typical implications of emissions and waste
Hydropower (low intensity)	Air pollution and soil pollution are limited and mainly related to the construction phase when dust and emissions from earth-moving activities, construction traffic, machinery, and vehicles generate localised air pollution. Soil pollution is typically associated with leaks or spills of petroleum products in machinery. Noise and vibration originate from construction activities and machinery. Rock blasting may be a highly localised source of noise and vibration specific to hydropower in the Electricity Supply Industry. During operation, handling of hazardous materials and waste (e.g., petroleum products) may be a source of soil pollution risks while air pollution is typically minimal and associated with vehicles. Power stations can be a significant source of noise.
Solar PV (low intensity)	Construction-related pressures are similar to hydropower (see row above) except rock blasting is not common. The construction period is typically substantially shorter for solar PV and this reduces the duration of the air pollution, soil pollution, noise and vibration.

Project type	Typical implications of emissions and waste
	During operation, there are very limited risks but hazardous material and waste (e.g., oil, electronic waste) require appropriate storage and disposal.
Co-generation (medium intensity)	Pressures related to air pollution, soil pollution, noise and vibration during construction are similar to the description for solar PV (see row above). During operation, the combustion of large volumes of biomass (typically bagasse) will result in air pollution such as emissions of particulate matter and various gaseous emissions such as carbon dioxide (CO_2), carbon monoxide (CO), nitrogen oxides (NO_x), sulphur dioxide (SO_2). Biomass can be considered as a renewable source if the biomass is produced sustainably and there should not be net greenhouse gas emissions. Power plants do generate significant noise, but the facilities are typically inside a sugar factory compound and hence the additional effects on the surroundings beyond the sugar factory operations are typically limited. Soil pollution risks are low and related to handling small volumes of hazardous materials and waste.
HFO, diesel (high intensity)	Pressures related to air pollution, soil pollution, noise and vibration during construction are similar to the description for solar PV (see above). During operation, the combustion of heavy fuel oil or diesel will result in air pollution such as emissions of particulates and various gaseous emissions (CO_2, CO, NO_x, SO_2, etc.) and smaller quantities of heavy metals (WBG, 2008). Greenhouse gas emissions from these non-renewable fossil fuels contribute to global warming and climate change. The power plants generate significant noise that may disturb the surroundings. Soil pollution risks are related to the handling of hazardous materials and waste, including substantial volumes of heavy fuel oil or diesel, as well as ash from the combustion of fossil fuels.
Transmission (low intensity)	Pressures related to air pollution, soil pollution, noise and vibration during construction are small and even lower than for solar PV projects (see above), highly localised and short-term. There may be noise from high-voltage lines and substations during operation but typically not to the extent of causing significant disturbance to the surroundings. In case the line is supported by treated, wooden poles (rather than steel towers), there may be risks of highly localised soil pollution where the pole is installed. Soil pollution risks are related to the handling of hazardous materials and waste, particularly transformer oil at substations that may contain PCBs or switchgear and circuit breakers that contain the greenhouse gas SF_6.

Project type	Typical implications of emissions and waste
Distribution (low intensity)	Pressures are similar to those for transmission lines above except that significant noise during operation is unlikely. The low-voltage lines typically use treated, wooden poles, which means the localised soil pollution risk is a typical yet small risk. The disposal of used poles represents a pollution risk to land and water. Wood pole treatment facilities represent a pollution risk depending on the location and nature of the landscape. Substation transformer oil risks are present, particularly oil contaminated with polychlorinated biphenyl (PCB) compounds.

3.1.3 State and Impact

The pressures result into changes to the environment and environmental conditions described as a "state". These changes in environmental conditions, which are often negative but can also be positive, in turn result into impacts on the environment, people or businesses that rely on the environmental resources or are otherwise affected by the environment. The "state" and "impact" vary a lot between the different Electricity Supply Industry segments (generation, transmission, and distribution) and within each segment due to site-specific conditions at different project locations. State and impact are described for each of the main thematic areas covered in Sections 4 to 9.

3.1.4 Responses and Recommendations

Following descriptions of state and impact in each of Sections 4 to 9, the specific responses currently being implemented in the Electricity Supply Industry are discussed. It is good practice to manage risks and adverse impacts in line with the mitigation hierarchy as is required by Section 115 of the National Environment Act, 2019, and Regulation 43 of the National Environment (Environmental and Social Assessment) Regulations, 2020. This structured way of addressing risks and impacts aims to prevent risks and impacts occurring in the first place. This also means that responses should target the early stages of the DPSIR framework as much as possible to proactively avoid and minimise as opposed to more reactively mitigate, compensate, or offset.

The mitigation hierarchy can be described by the following steps that are ordered in terms of priority and illustrated in Figure 3-2 below:

1) Avoidance: First consider and propose locations (site selection) for project structures and selection of project technologies and approaches to avoid risks and impacts.

2) Minimise: Thereafter, consider and propose project modifications and adaptations, including technological solutions, construction practices and operational procedures, to reduce risks and impacts that cannot be avoided.

3) Mitigate: Thereafter, consider and propose mitigation measures to reduce risks and impacts that cannot be avoided or minimised.

4) Compensate or offset: Finally, consider and propose potential compensation or offsets where risks and impacts cannot be adequately avoided, minimised or mitigated further, that is, where there are significant residual risks and impacts after the mitigation step in this hierarchy.

It is important to keep in mind that adaptations and measures in the mitigation hierarchy should be technically possible and should not make the project economically unviable. The measures should also be effective in meeting intended objectives and they should as much as possible be cost-efficient and agreed to by stakeholders.

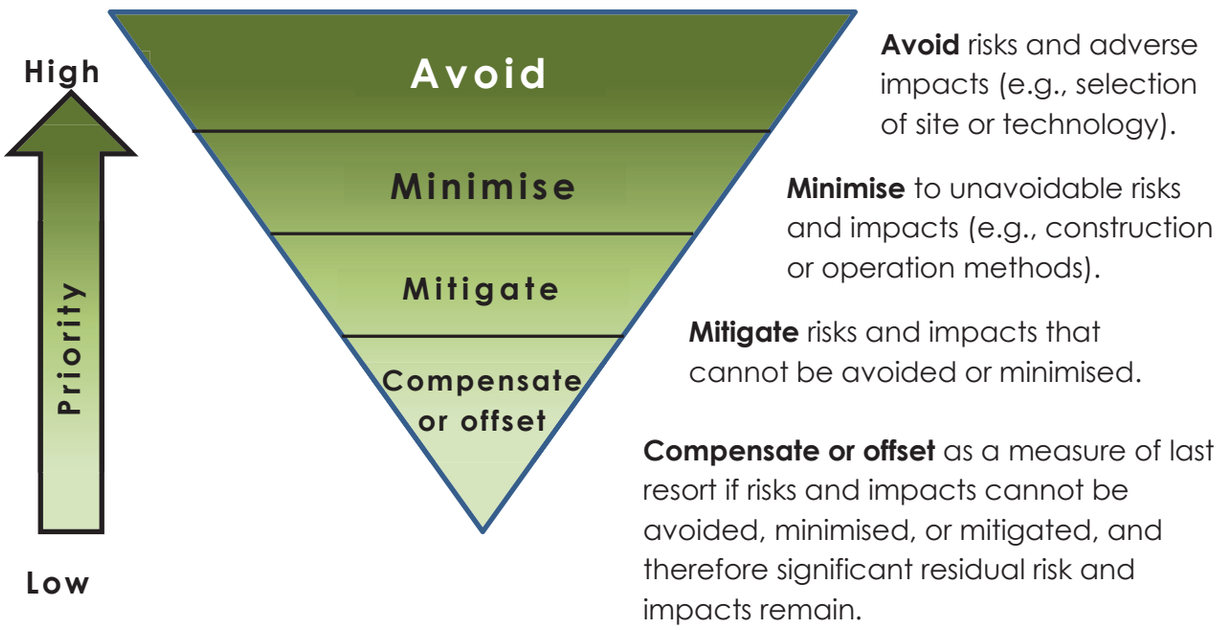


Figure 3-2: Illustration of the mitigation hierarchy that should be applied when responding to risks and impacts.

In addition to describing current responses, Sections 4 to 9 also provide forward-looking recommendations for the various thematic areas that go beyond the current responses.

3.2 Issues Impacting the Electricity Supply Industry

Rather than looking at the Electricity Supply Industry's impacts on the environment, this subsection highlights environmental and social issues that are impacting the Electricity Supply Industry infrastructure and operations. These issues are not a focal theme for this ESISOER but a relevant part of the Electricity Supply Industry–environment interface.

Some of the issues affecting the Electricity Supply Industry include:

- Alien invasive species – water hyacinth: The introduced water hyacinth has proliferated in many Ugandan water bodies. This exotic water plant presents major challenges to the generation segment of the sector, particularly in reservoirs of power plants along the River Nile (Nalubaale, Kiira, Bujagali, Isimba, and Karuma) and for the Kikagati hydropower project on the Kagera River (see Figure 3-3). Substantial costs are incurred to remove and dispose the water hyacinths, and this aquatic weed has resulted in outage as the power plants intermittently may need to reduce output or temporarily stop to remove hyacinth clogging at trash racks.

- Theft and vandalism: Theft and vandalism result in damage to equipment, which thereafter needs to be replaced. The damaged equipment causes a waste problem. This has been a problem particularly in the distribution grid for a considerable time. In recent years, there has been a large increase in the cases of vandalism for the high-voltage network as well. For instance, between May 2021 and November 2022, two hundred and nine (209) high-voltage transmission towers were vandalised (see Figure 3-4 below). Items being vandalised or stolen range from small installations such as stay rods to large equipment such as transformers and transmission

towers. These vandals compromise the reliability, continuity and stability of the power supply, which has significant consequences on Uganda's economy. The costs to replace equipment contribute to increasing the electricity tariff where such costs are funded through the tariff.

- Encroachment: Encroachment by local people on the land acquired by Electricity Supply Industry projects may also adversely affect environmental conditions on the project land.

- Floods and drought: Natural climatic variation as well as human-induced climate change are affecting the Electricity Supply Industry installations and operations. Drought or low flow periods reduce hydropower generation substantially, as was the case 15-20 years ago when substantial thermal capacity had to be installed and load shedding was prevalent. Some of the medium and small hydropower projects also must stop operation during dry seasons due to insufficient river flow. Flooding has caused damage and downtime for multiple small hydropower projects. Future climate change and instability pose risks both to generation projects and the transmission and distribution networks that may be damaged during extreme weather events.

- Old infrastructure: Old infrastructure that had been insufficiently maintained resulted in substantial grid losses in the past. The power losses meant that additional generation capacity and associated power evacuation lines had to be installed to compensate for the losses. The losses therefore indirectly created additional pressures on the environment. The sector, however, has worked to reduce losses in the grid, particularly in the distribution grid. Considerable reductions have been observed over the past 20 years. Nevertheless, losses are still significant and further loss reduction efforts are required.



Figure 3-3: Removal of water hyacinths at the trash rack of the Kikagati Hydropower Plant using the trash rake system (upper photo, by GET FiT Uganda) and manual removal at the Nalubaale dam (lower photo, by UEGCL).

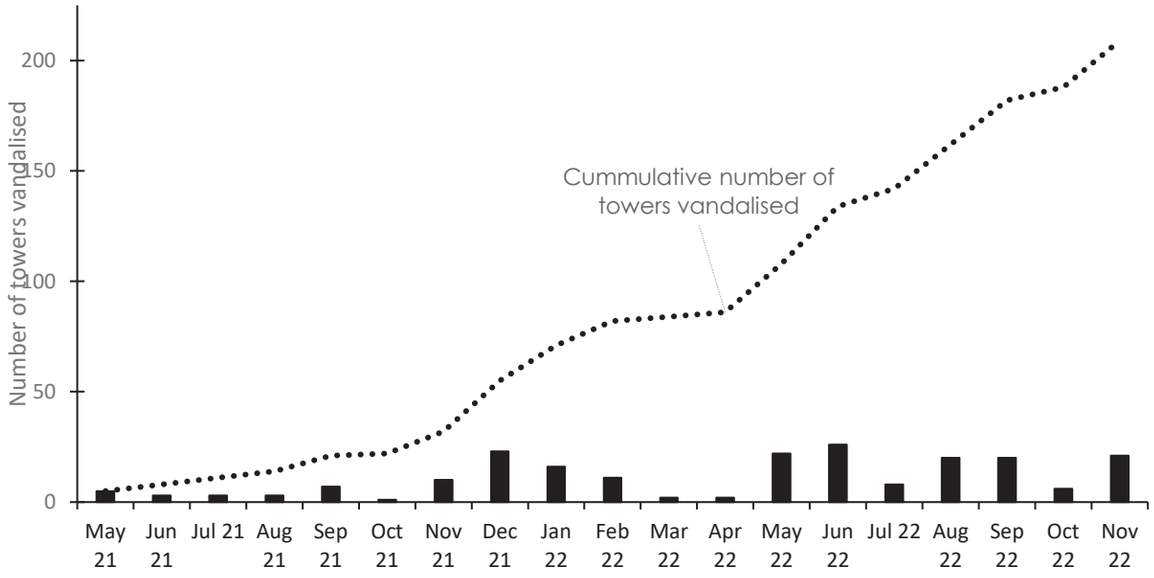


Figure 3-4: Number of high voltage transmission towers vandalised between May 2021 and November 2022 (source: UETCL, 2022).

3.3 References

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WATER RESOURCES



Damming and diversion of water for hydropower generation, Pader District (photo by Arpe Limited).

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WATER RESOURCES



Damming and diversion of water for hydropower generation, Pader District (photo by Arpe Limited).

4 WATER RESOURCES

4.1 Introduction

4.1.1 Background

Uganda is rich in freshwater resources across much of the country, including the vast Lake Victoria, the White Nile River, and complex systems of rivers and wetlands. This valuable resource is subject to different development pressures necessitating well-planned actions.

One of the objectives of the Water Act Cap 152 is to allow for the orderly development and use of water resources for purposes other than domestic use, such as the generation of hydroelectricity or geothermal energy, and preservation of flora and fauna and recreation in ways which minimise harmful effects to the environment.

Water is essential for electricity generation as hydropower provided more than 90% of the country's grid electricity produced in 2023. Water resources are critical for power generation and the entire Electricity Supply Industry. All rights to investigate, control, protect, and manage water in Uganda for any use are vested in the Government and are exercised by the Minister responsible for water and environment and the Director responsible for water development in line with the Water Act Cap 152.

This section highlights the linkages between power generation and water resources using the DPSIR framework while presenting the benefits and challenges arising from Electricity Supply Industry activities on water resources.

Uganda's surface and groundwater resources cover an area of 36,280 km^2 (15 per cent) of the 241,500 km^2 total area of the country. Surface water resources are relatively abundant in Uganda with the flow of the Nile exceeding 25 km^3 per year, and large volumes of water stored

in the various lakes in the country. Water levels are primarily replenished by rain and vary over time (NEMA, 2016).

The major lakes include Lake Victoria, Lake Kyoga, Lake Albert, Lake George, and Lake Edward. The Nile River ultimately drains all these areas as the Nile runs northwards into South Sudan. This also makes Uganda a country with transboundary water resources, including Lake Victoria, which is shared with Kenya and Tanzania, and Lakes Albert and Edward, the latter shared with the Democratic Republic of Congo. This transboundary nature affects the quality and quantity of the water resource as well as makes water resource management complex.

Approximately 69% of the renewable water resources originate from neighbouring states, making transboundary water resources issues important. Approximately 13.6 km^3/yr and 29.8 km^3/yr originate nationally and from neighbouring countries, respectively (MWE, 2013a).

4.1.2 National Legal Frameworks

Water resources in Uganda are managed by the Ministry of Water and Environment, and the operations are supervised directly by the Directorate of Water Resources Management. Important national legal frameworks that govern the use of water resources in Uganda include:

1) Constitution of the Republic of Uganda, 1995, as amended.
2) Water Act Cap 152 (currently under review).
3) National Environment Act, 2019.
4) Water Resources Regulations, 1998.
5) Water (Waste Discharge) Regulations, 1998.
6) National Environment (Standards for Discharge of Effluent into Water or Land) Regulations, 2020.
7) National Environment (Environmental and Social Assessment) Regulations, 2020.
8) National Water Policy of 1999 (currently under review).

Water resources are very important for key sectors such as power generation, agriculture, domestic water supply, fisheries, and industries.

Therefore, frameworks have been developed for a more integrated approach to water resources management to consider different sectors' interests in and impacts on water resources. Key in these efforts is catchment-based water resources management, including the development by the Ministry of Water and Environment of catchment management planning and water source protection planning (MWE, 2013a, b, c, d, e, f; MWE, 2019). There has also been increasing recognition of the criticality of climate change mitigation and adaptation, which are discussed in Section 9 below.

4.2 Driver and Pressures

The main driver in the Electricity Supply Industry resulting in pressures on water resources is the societal need for electricity (see Section 3.1.1 above). For water resources, the resulting main pressures are:

- Water abstraction for hydropower generation.
- Changes in the timing of river flows due to hydropower reservoirs or hydro-peaking.
- Effluent releases resulting in water quality changes (pollution) during construction activities or operation of generation projects, and waste disposal into water bodies.
- Sediment discharges (flushing) into rivers.
- Competition with other water users, such as agriculture, domestic water supply, municipalities, industries, and environmental conservation.

Figure 4-1 summarises key elements in the Electricity Supply Industry's effects on water resources as illustrated by the DPSIR model.

4.3 State of the Environment

4.3.1 Reduced River Flow

Hydropower projects can lead to a reduction in river flow through different mechanisms. The construction of dams or weirs will result in the diversion of water for power generation and in some instances also storage of water in reservoirs to release water in a different period when the stored water is needed.

In Uganda, the most common reduction in rivers' water flow is caused by construction of a dam or weir to divert water from a river into a waterway (canal, pipeline, or tunnel). In hydropower projects, the waterway can range from less than 100 m to 11 km before the water is returned to the river via the tailrace canal (see Table 4-1 and Figure 4-2). Most of the water is diverted into the waterway and only the mandatory minimum flow (environmental flow, or eflow) remains in the river section that is bypassed (see Figure 4-2). Most hydropower projects in Uganda result in a flow reduction of more than 90% compared with the mean annual flow in the diverted river section.

During periods of substantial rainfall, the river flow may increase beyond the capacity of the hydropower project's turbines and therefore result in spilling of excess water over the dam or weir. In such periods, the section of the river whose water was diverted into the waterway will have more water and the impact caused by the diversion is temporarily reduced (see Figure 4-3). Downstream of the diverted river section, that is, downstream of the tailrace, the natural river flow regime is typically maintained in run-of-river projects where the inflow is used by the project and released continuously rather than stored in a reservoir for later use.

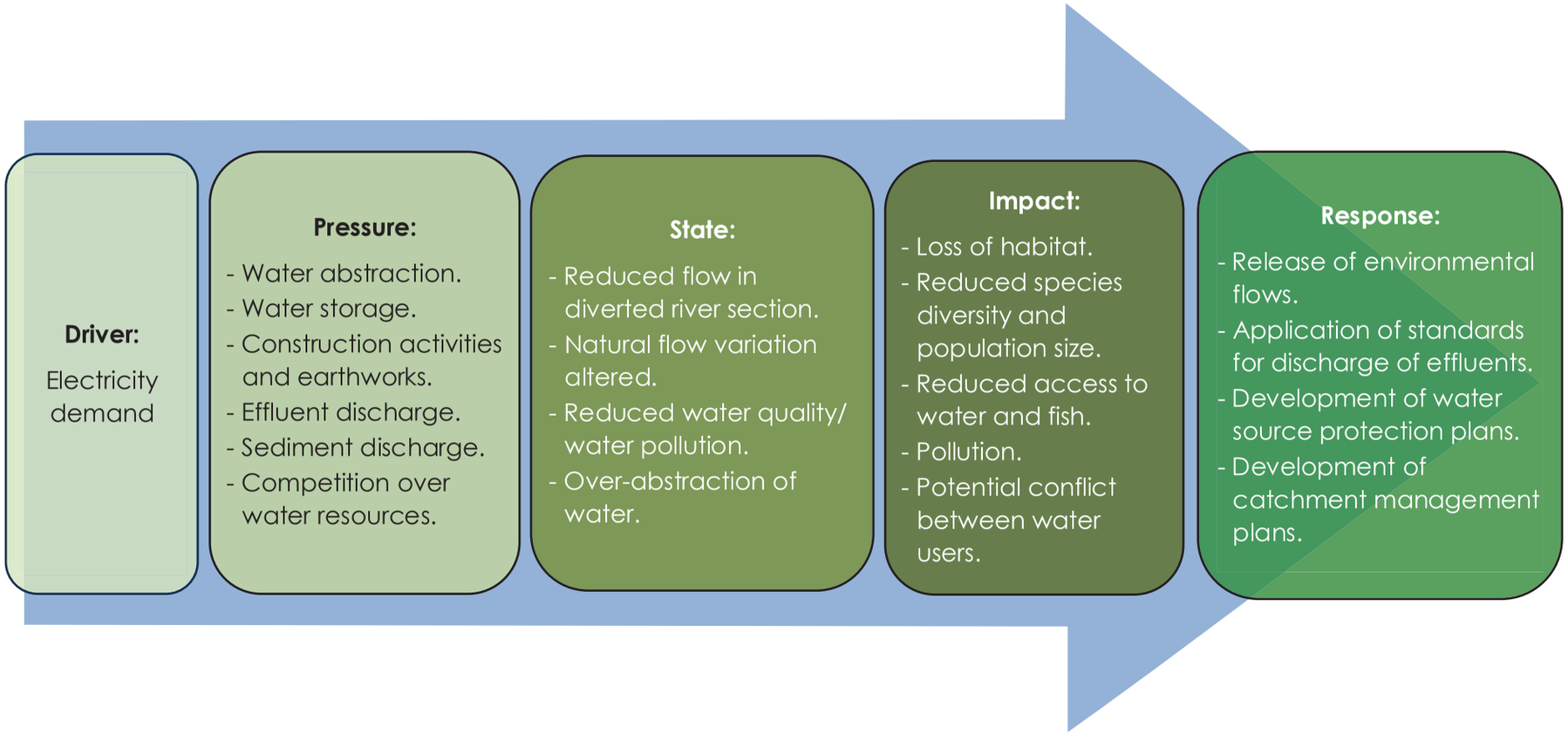


Figure 4-1: Key elements in the DPSIR model summarising the main pressures, states, impacts and responses concerning the Electricity Supply Industry's effects on water resources.

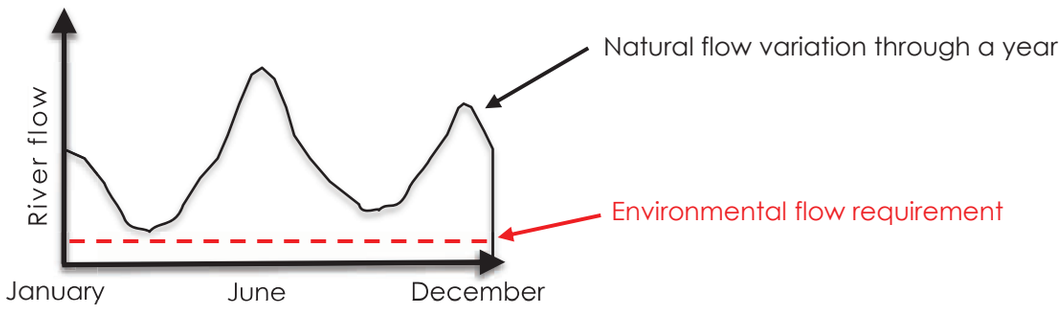


Figure 4-2: Illustration of natural river flow through the year (black line) and the environmental flow released into the diverted river section (red dotted line) assuming the turbines can use all water beyond the eflow.

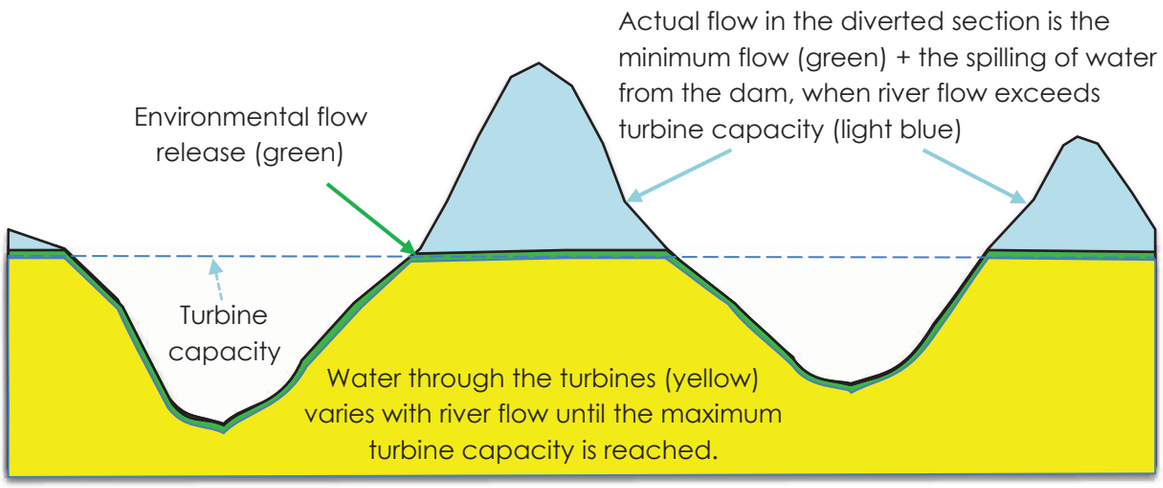


Figure 4-3: Illustration of flow level in the diverted river section for a run-of-river hydropower project, which much of the year is only the small environmental flow (thin, green band) that in periods of high flow that go beyond the turbine capacity is supplemented by water spilling over the dam (light blue areas).

The creation of a water reservoir behind a dam can hold back water, temporarily and thereby reduce river flow downstream of the hydropower project. This happens when the releases for hydropower and environmental flow combined are lower than the inflow to the reservoir (storing water). When the release from the reservoir is greater than the inflow (reducing water storage), the flow downstream of the hydropower project will be artificially raised above the natural inflow (see also Section 4.3.2 below).

Establishment of a reservoir will also inundate a section of the river upstream of the dam or weir. This river section may change its characteristics substantially from a river environment to more of a lake environment. Table 4-1 and Figure 4-4 below also show the length of river sections inundated by a reservoir with the ecological impacts discussed further in Section 5. As can be seen in Table 4-1 and Figure 4-4, the length of inundated river sections tends to dominate over the diverted river sections for large and medium hydropower projects. This is due to a larger dam structure. For the small hydropower projects, the diverted river sections dominate over inundated river sections due to the designs of dams or weirs constructed that do not inundate significant areas upstream.

The alterations in natural river flow can result in significant consequences for water users and ecosystems by changing aquatic habitats, disrupting natural flow regimes that support biodiversity, and impacting downstream communities or water users that rely on the natural flow regime along the diverted river section. Striking a balance between harnessing the benefits of hydropower and mitigating environmental impacts requires careful planning, adaptive management, and the incorporation of sustainable practices to ensure the long-term health of river ecosystems and the well-being of communities and water users. The DWRM is promoting the integrated approach to water resources management to consider different sectors interests and impacts on water resources. The Ministry of Water and Environment has developed tools for catchment management planning and water source protection planning (MWE, 2013a, b, c, d, e, f; MWE, 2019).

On the other hand, the environmental flow release for the diverted river section is intended to ensure a minimum of water for potential water users and ecosystems. Several cases have been identified where hydropower projects have abstracted excessive water volumes and not released the required environmental flow as determined in the water abstraction permit conditions by the DWRM. Such unauthorised water abstraction compromises the societal choice of how to balance power generation and downstream water users and ecosystems. It is important to note that the excess water abstracted represents additional income to the

hydropower project owner. Conflicts over water can be triggered by excessive water abstraction by a hydropower project or cumulative abstractions by multiple water users.

Problems for downstream water users, including for a downstream hydropower project in a cascade where multiple projects are located on the same river, can also arise from technical problems at an upstream hydropower project. For instance, a stop in power generation (e.g., due to an internal power station problem, or a problem with the power line) will stop flow through the turbines and therefore stop the return of water to the river and downstream water users. Such a drop in river flow can trigger stops in downstream projects relying on the continuous flow from upstream. This is the case with the Mubuku River cascade of hydropower projects in Kasese District.

Table 4-1: Diverted and inundated river sections as well as storage capabilities at hydropower projects.

	Hydropower Project	Diverted river (km)[a]	Inundated river (km) [b]	Total river affected (km)[c]	Large dam[d]	Reservoir (y/n)[e]	Storage (y/n)[f]	Hydro-peaking (y/n) [g]
Large	Bujagali	0.0	7.6	7.6	Yes	Yes	No	No
	Isimba	0.0	17.5	17.5	Yes	Yes	Yes	Yes
	Karuma	11.0	20.0	31.0	Yes	Yes	No	No
	Kiira	0.0	4.2	4.2	Yes	Yes	Yes	Yes
	Nalubaale	0.0	3.3	3.3	Yes	Yes	Yes	No
Medium	Achwa 1	3.9	4.1	8.0	Yes	Yes	No	No
	Achwa 2	3.3	0.6	3.9	No	Yes	No	No
Small	Bukinda	1.8	0.3	2.1	No	Yes	No	No
	Ishasha	1.3	0.4	1.7	No	Yes	No	No
	Kabalega	2.5	0.7	3.2	No	Yes	No	No
	Kakaka	2.1	0.0	2.1	No	No	No	No
	Kikagati	0.0	3.7	3.7	No	Yes	No	No
	Kyambura	3.4	1.0	4.4	No	Yes	No	No
	Lubilia	3.1	0.1	3.2	No	No	No	No
	Mahoma	2.1	0.2	2.3	No	Yes	No	No
	Mpanga	1.8	1.0	2.8	No	Yes	No	No
	Mubuku 1	7.1	0.0	7.1	No	No	No	No
	Mubuku 2	5.5	0.0	5.5	No	No	No	No
	Mubuku 3	8.2	0.0	8.2	No	No	No	No
	Muyembe	1.7	0.3	2.0	No	No	No	No

Unclassified

	Hydropower Project	Diverted river (km)[a]	Inundated river (km)[b]	Total river affected (km)[c]	Large dam[d]	Reservoir (y/n)[e]	Storage (y/n)[f]	Hydro-peaking (y/n)[g]
	Muvumbe	2.5	0.2	2.7	No	No	No	No
	Ndugutu	8.5	0.0	8.5	No	No	No	No
	Nkusi	0.9	0.3	1.2	No	Yes	No	No
	Nyagak 1[h]	1.7	0.9	2.6	No	Yes	Yes	Yes
	Nyamwamba 1	1.6	0.0	1.6	No	No	No	No
	Nyamwamba 2	3.5	0.0	3.5	No	No	No	No
	Nyamagasani 1	5.4	0.0	5.4	No	No	No	No
	Nyamagasani 2	4.3	0.0	4.3	No	No	No	No
	Rwimi	3.1	0.6	3.7	No	Yes	No	No
	Sindila	3.7	0.0	3.7	No	No	No	No
	Siti 1	4.2	0.0	4.2	No	No	No	No
	Siti 2	4.3	0.0	4.3	No	No	No	No
	Waki	3.2	0.1	3.3	No	No	No	No
Micro	Bwindi	0.3	0.0	0.3	No	No	No	No

Source: ERA Database, 2023.

Unclassified

Notes to Table 4-1:

[a]: Diverted river section: River section between dam/weir where water is abstracted and tailrace outlet where water is returned to the river.

[b]: Inundated river section: River section upstream of dam/weir that is inundated/subject to backwater effects and changes from river to lake-like conditions. Inundated sections less than 50 m long appear as "0.0".

[c]: Diverted river section plus inundated river section.

[d]: Large dam: Dam with a height of 15 m or more from lowest foundation to crest, or a dam between 5 and 15 m impounding more than 3 million m^3.

[e]: Reservoir: Refers to impoundment due to a dam/weir that is significantly larger than the pre-project water volume in the inundated area.

[f]: Storage: Refers to a reservoir that contains a substantial volume of water (irrespective of whether the stored volume is actively used to store water for later use).

[g]: Hydro-peaking: Active use of storage to increase/reduce flow through turbines to meet variation in electricity demand irrespective of inflow to the reservoir. Note: Isimba can operate for approximately 3 hours based on the stored volume of water but is normally not operated as a peaking plant by drawing down the reservoir. Kiira typically increases output to meet peak demand. This means that inflow to Bujagali downstream increases and output at Bujagali increases to avoid spilling of water at Bujagali.

[h]: Nyagak 1: This project has been operating in island mode, that is, it has operated independently from the main grid as an off-grid system. The generation has therefore been adjusted to meet the demand for electricity within the limitations of the relatively small reservoir and storage capacity, including low generation and low flow from the turbines in low-demand periods such as during the night. As the project has recently been connected to the national grid, the operation pattern that resembles hydro-peaking will likely change towards a non-hydro-peaking operational mode.

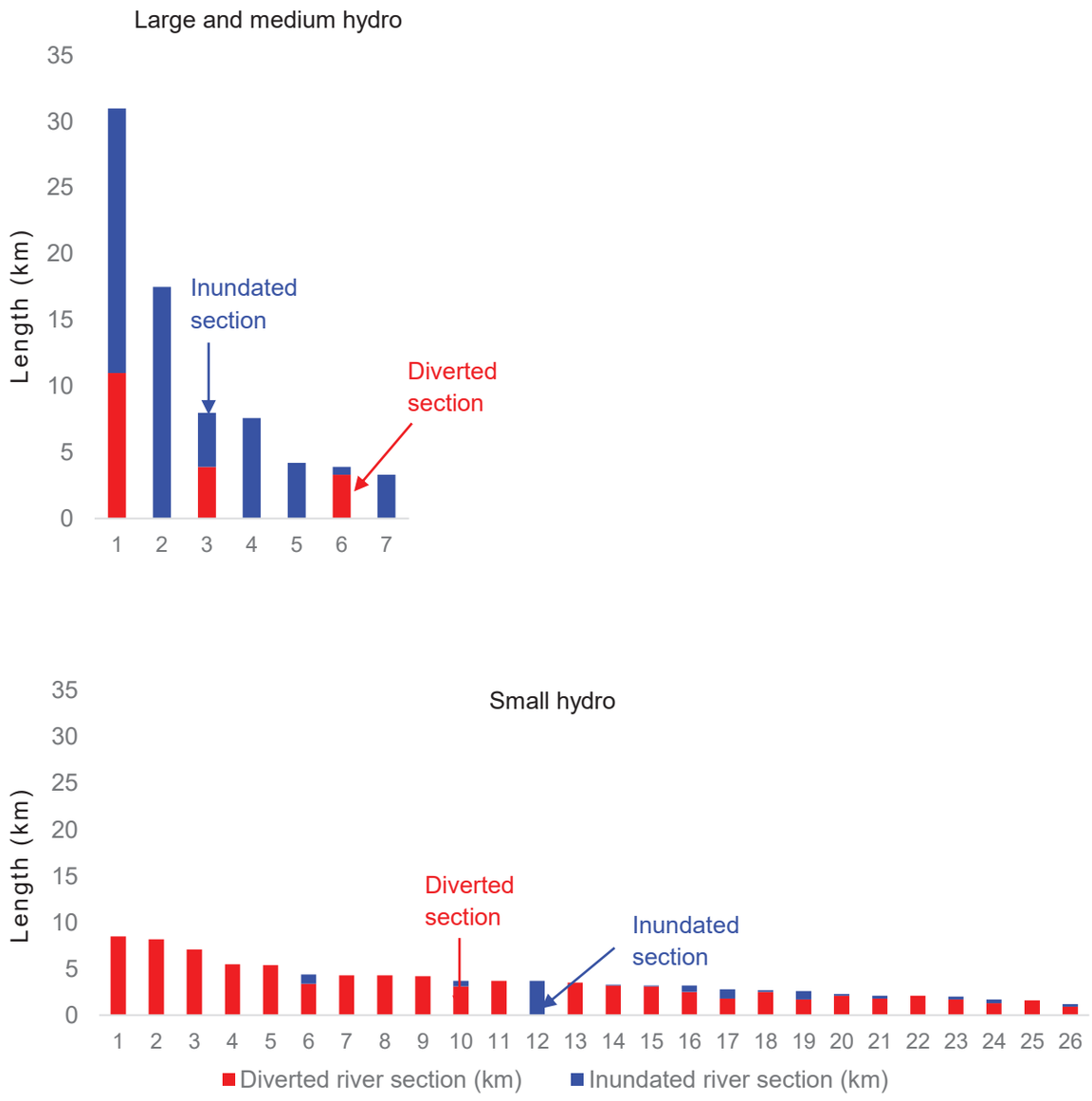


Figure 4-4: Length (in km) of diverted river sections downstream of dam/weir and inundated river sections upstream of dam/weir for seven (7) large and medium-sized hydropower projects (upper graph) and 26 small hydropower projects (lower graph).

4.3.2 Natural River Flow Variation Altered

Longer-term Storage

By regulating the release of water from reservoirs, hydropower projects alter the natural flow variation of rivers. Large reservoirs can enable storage of water from the rainy season with high natural inflows and then release water during the dry season when natural inflow is low. This evens

out of the natural, seasonal flow variation by reducing flows downstream of the hydropower project during the rainy season (period of storage in the reservoir) and increasing the flows downstream during the dry season (drawing water from reservoir storage). To serve such a function, the reservoir needs to have a large live storage available that can be drawn upon. Only Lake Victoria is sufficiently large to serve such a function in Uganda.

Such a controlled release regime results in a more consistent and predictable flow pattern, deviating from the natural variability that rivers experience due to seasonal changes and precipitation events. The altered flow regimes can have profound ecological consequences, affecting aquatic habitats, sediment transport, nutrient cycling, and the overall health of river ecosystems that have adapted to natural flow variations over time. This change in the natural flow regime can reduce flooding risk in the rainy season and increase available water during the dry season for downstream water users.

Short-term Storage for Hydro-peaking

During periods of low electricity demand water can be retained in the reservoir, reducing downstream flow compared with the natural inflow. Conversely, when electricity demand is high, water beyond the natural inflow can be tapped from the reservoir to generate extra power to meet peak demand. This will increase downstream flow from the power station. Such short-term adaptation to electricity demand with concurrent substantial changes in river flow downstream is often referred to as hydro-peaking. This mode of operation also requires a significant live storage in the reservoir, but the volume may be substantially smaller than in the case of long-term storage.

Hydropower projects in Uganda typically are unable to undertake hydro-peaking due to the lack of a significant live storage available for use. Variation in electricity demand is met by the Victoria Nile hydropower cascade, where the upstream Kiira Hydropower Plant increases electricity generation and thereby also downstream flow, after which the Bujagali and Isimba Hydropower Plants approximately 8 km and 45 km

downstream on the Victoria Nile, respectively, also generate more electricity due to a higher inflow.

4.3.3 Reduced River Water Quality

Physical, chemical, and biological water quality parameters may be altered due to Electricity Supply Industry projects. Both the construction and operation of hydropower and other projects in the sector may affect water quality in rivers, lakes, and wetlands. Construction-related changes to water quality may result from excavations and other earth-moving activities, land clearing, coffer dam construction and removal at hydropower projects, leaks and spills related to construction machinery or storage areas, and camp areas with sanitary facilities.

Hydropower projects will also affect water quality during the operation phase. The extent of change in water quality depends on the project design characteristics (e.g., run-of-river or storage reservoir, shallow or deep intake in reservoirs), the operational mode (e.g., hydro-peaking or base load), how sediment flushing is undertaken, whether there are leaks and releases of polluting substances, the morphology of the affected river (e.g., steep or flat river downstream, river banks prone to erosion or not), and the extent of tributaries and pollution input downstream of the dam/weir.

Large reservoirs are more likely to alter water quality both within and downstream of the reservoir than small reservoirs or projects with no reservoir. The extent to which water quality is altered varies with several factors and needs to be considered based on project-specific circumstances. Typically, the run-of-river hydropower projects in Uganda result in limited water quality changes during operation, partly because there are no large reservoirs except Lake Victoria.

Hydropower dams and reservoirs capture sediments (suspended sediments and bedload), and the sediments gradually accumulate in the reservoir or intake pond. Sediments may need to be removed to avoid damage and costly repairs to structures or equipment (e.g., abrasion of turbines), and therefore sediment flushing through the bottom gate in the dam wall is undertaken in several hydropower

projects. Sedimentation basins are designed to capture sediments that has entered the waterway of a hydropower project and also need regular sediment flushing. Smaller volumes of sediments may also require removal from intakes and forebays at hydropower projects. Sediment flushing at dams in particular but also at sedimentation basins can change the water quality and quantity downstream abruptly.

The bagasse-fired co-generation plants are part of sugar factory complexes, which are associated with water pollution in the form of substantial volumes of effluent mainly from the sugar factories. Untreated effluent will typically contain large amounts of organic compounds that result in oxygen consumption and potentially oxygen depletion in the receiving water body, which will result in the death of many organisms. This results into poor water quality and reduces the suitability of water for different uses unless appropriately treated before release. The wastewater from sugar complexes also contains oil and grease that require separation from the wastewater before release.

Fossil fuel power plants also generate wastewater that requires treatment, for instance from blowdown, ash handling, or fuel handling areas. Volumes of effluent are typically moderate or small.

4.4 Impacts

Due to the nature of hydropower projects and hydropower's dominant role in electricity generation in Uganda, most impacts on water resources are associated with hydropower. However, hydropower projects' impacts on water resources can vary substantially with project-specific characteristics and the characteristics of the water resources (IFC, 2018a, b; IHA, 2020). Typical impacts may include:

1) Reduced access to water: River diversion is experienced in most hydropower projects and will typically reduce the availability of water along the diverted river sections for individuals or water users with abstraction points such as gravity flow schemes. Reduction in access can be due to reduced water volume, reduced water quality, or reduced access to the river due to access restrictions introduced by hydropower projects for safety or other reasons. Conflicts between water users may arise.

2) Change in the flow regime: Impacts on downstream flow regimes may adversely affect downstream water users such as domestic water use, abstraction for irrigation, abstraction for hydropower generation, or abstraction for other activities. Changes in flow regimes beyond the diverted river section are less common in Uganda due to the run-of-river nature of most hydropower projects.

3) Habitat conversion and degradation: Habitat degradation and conversion for aquatic and terrestrial biodiversity may occur as result of reservoir creation and inundation that remove terrestrial habitats and transform river habitats to lake-like environments (see Figure 4-5). Changes in the flow regime downstream of a hydropower project will change habitat characteristics (e.g., due to hydro-peaking), and river diversion between the dam/weir and tailrace can substantially reduce available river habitats (see Section 5 for more information about biodiversity).



Figure 4-5: Illustration of habitat conversion by the Isimba hydropower project. The left satellite image shows the dynamic Nile River with a variety of aquatic habitats (March 2014, before inundation). The right satellite image shows the lake-like reservoir after inundation (September 2020), which is a much more homogenous environment with changes in habitats and species (source: Google Earth).

4) Accumulation and removal of sediment. Dams and reservoirs capture suspended sediments and bedload in the river. The accumulated sediments may require intermittent removal through sediment flushing from the dam (opening sediment flushing gates), which can result in abrupt, large increases in sediment load downstream and that adversely impact fish and other aquatic life. A mass fish death event due to sediment flushing has been observed downstream a hydropower project in Uganda. Capturing sediments in reservoirs reduce sediment load downstream under normal conditions. The reduced sediment content in river water can lead to "sediment-hungry" rivers that result in erosion, riverbed deepening, and riverbank collapses downstream of the dam. This may affect ecosystems and local people using the river.
5) Leaks and pollution: Construction activities with vehicles and machinery involve the use of fuel and oils that can cause pollution. During the operation phase, hydropower projects as well as other Electricity Supply Industry installations (e.g., transmission and distribution transformers) use oils and other petroleum products and ERA has registered examples of leaks, accidents, or poor management. Any hazardous materials ending up in the water can adversely affect local people and the environment (see Figure 4-6).
6) Thermal pollution: Release of water with substantially altered temperature is not considered a substantial impact in the Ugandan context as there is limited cooling water releases.
7) Land use changes and resettlement: Reservoir creation and inundation of upstream river sections can result in loss of agricultural land, loss of access to natural resources, and resettlement (see Section 6 for more information about the social environment).

While hydropower projects are the main source of impacts on water resources in the Electricity Supply Industry, co-generation projects that are integral parts of sugar factory complexes are associated with sugar factory effluents. If these effluents have not been adequately treated before release to the environment, there will be pollutant releases that reduce the suitability of the water for most uses. Oxygen depletion due

to high organic matter content in effluents can also result in the death of aquatic life.



Figure 4-6: Oil spill at a decommissioned transformer at Lira substation (upper photo, by ERA) and oil spill at the 132 kV Namanve substation (lower photo, by ERA).

4.5 Responses

Lead agencies such as DWRM and NEMA have developed regulations and approval procedures that define conditions and requirements to avoid and minimise impacts on water resources. These responses address impacts on water quantity (availability) as well as impacts on water quality. For hydropower projects, typical conditions for project approval include the requirements to development water source protection plans.

To address the impacts associated with river diversion and reduced flow, the approval of hydropower projects is typically conditional on the continuous release of a project-specific environmental flow from the dam or weir area (Figures 4-7 and 4-8). DWRM defines the eflow minimum requirement that is reflected both in the Construction Permit during the construction phase and in the Surface Water Abstraction Permit for the operations and maintenance phase.

This environmental flow is intended to ensure the water users and ecosystems downstream of the intake have access to a minimum of water in the river. This important measure has at times been compromised by poorly functioning mechanisms to release the required environmental flow, and examples have been noted where the required environmental flow has not been released and the relevant agencies have not been notified or have been provided with incorrect records of the environmental flow release.



Figure 4-7: Different arrangements to release and monitor environmental flow at hydropower projects. Upper left photo: Pipe through the body of the dam with flow meter on pipe (Rwimi). Upper right photo: Partial release of environmental flow through an upstream fish passage with water level sensor (Kikagati). Lower photo: Pipe from a chamber in the waterway/canal with flow meter on pipe at Kyambura Hydropower Plant (photos by GET FiT Uganda).



Figure 4-8: Minimum flow release through a V-notch overflow weir at Nyamwamba Hydropower Plant (photo by GET FiT Uganda).

A review of several small hydropower projects[1] showed that the level of environmental flow varies widely between projects and is often very low (see Figure 4-9), indicating a need for further clarity on criteria and guidance to determine the environmental flow. To compare environmental flow levels in rivers of very different sizes, the environmental flow level in Figure 4-9 is illustrated as the proportion that the environmental flow requirement represents of the mean annual flow in the affected river.

[1] The 15 hydropower projects referred to here are Kikagati, Kyambura, Lubilia, Mahoma, Muvumbe, Ndugutu, Nkusi, Nyamagasani 1, Nyamagasani 2, Nyamwamba, Rwimi, Sindila, Siti 1, Siti 2, and Waki.

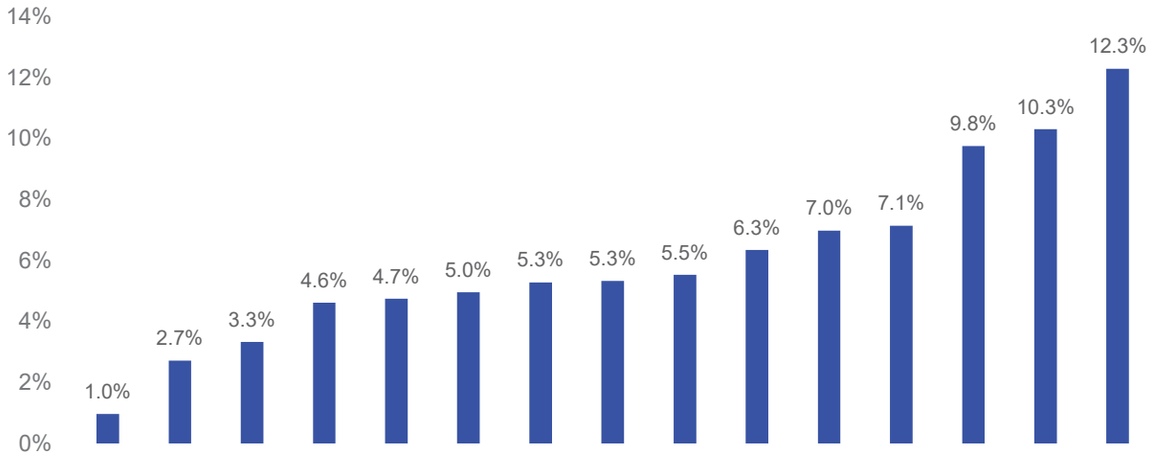


Figure 4-9: Level of environmental flow required for 15 small hydropower projects in operation, measured as the proportion of the mean annual flow in the affected river.

The large differences in environmental flow requirements do not appear to be clearly related to the length of river affected by the river diversion, the environmental values associated with the river or the extent of human water use. At the same time, it is important to note that there is no fixed value that is appropriate. Because river characteristics such as water interests vary from river to river, it is natural that the proportion of river flow allocated as environmental flow varies from river to river.

Internationally, a general "rule of thumb" is that an allocation of 10-30% of the mean annual flow is likely to be required to maintain the basic functionality of aquatic ecosystems. If the proportion is below 10%, then serious adverse impacts will be expected. Internationally it is also recognised that the determination of the environmental flow is a societal choice that involves trade-offs between different societal interests.

Impacts from effluents and pollution are typically managed through requirements to prevent pollution in line with existing regulations, for instance the National Environment (Standards for Discharge of Effluent into Water or Land) Regulations, 2020. Required measures are typically avoidance of direct runoff from construction sites to water bodies, not allowing direct releases of polluting substances to water bodies, installation of oil/water separators (Figure 4-10), appropriate storage and disposal of hazardous waste (see Figure 8-5 on page 253), and installation

of effluent treatment plants at sugar factories (see Figure 8-2 on page 247). Wastewater discharge permits are to be obtained from DWRM where there are wastewater releases to the environment.



Figure 4-10: An oil/water separator with three chambers (one chamber covered by incomplete roof) under construction to remove any oil leaks from power station or switchyard mixed with water, prior to release the water to the environment.

To reduce the impacts from sediment flushing from hydropower projects, plant operators are encouraged to consider sediment management at the planning and design stage as well as at the operational stage, including having a sediment flushing/management plan that clarifies:

1) Ways of monitoring and determining the level of sediment accumulation in the impoundment and other structures such as in the sedimentation basin.
2) Timing of sediment flushing, which should be during high flow periods, when the natural sediment load in the river is high.
3) Coordination with the downstream water users (other hydropower plants, local communities, water supply schemes, etc.).
4) Detailed instructions for carrying out sediment flushing operations.
5) Requirement for water quality sampling before, during and after sediment flushing.

Important efforts are undertaken by hydropower projects and other Electricity Supply Industry projects to avoid and minimise water pollution. However, the operationalisation of requirements and permit conditions and translation of these requirement into appropriate, site-specific measures are at times ineffective, resulting in pollution.

Lead agencies undertake site inspections and require monitoring and reporting by licensed projects. For instance, hydropower projects are required to report to DWRM on the water abstraction and environmental flow release, and projects with environmental approval are required to undertake Annual Environmental Audits by registered experts. The effectiveness of such reporting is at times reduced by gaps in environmental monitoring by projects and the absence of purposeful, systematic monitoring to identify changes that can be attributed to the project in question.

4.6 Recommendations

The most substantial water resource impacts from the Electricity Supply Industry are typically caused by hydropower projects. The recommendations listed below are therefore mainly concerned with hydropower.

4.6.1 Policy

1) Environmental Flow: The DWRM, in collaboration with ERA and NEMA, should develop more specific requirements and supporting guidance for environmental flow releases at hydropower projects, including for hydro-peaking operations. The requirements and guidance should cover environmental flow assessments, release arrangements, monitoring, and documentation. Inter-agency collaboration is needed for practical and coordinated requirements.
2) Hydropower Pollution: The DWRM, in collaboration with ERA and NEMA, should develop more specific requirements and supporting guidance for specific hydropower facilities at risk of causing pollution, including sediment flushing from dams, releases from powerhouses, releases from switchyards, and the designs of oil/water separators.

4.6.2 Implementation and Actions

1) Environmental Flow: DWRM, in collaboration with ERA and NEMA, should review existing environmental flow release conditions in

permits and existing arrangements at projects to clarify conditions and improve arrangements where necessary.

2) Hydropower Pollution: NEMA, in collaboration with ERA and DWRM, should review existing hydropower facilities at risk of causing pollution, including sediment flushing, powerhouses, switchyards, and oil/water separators, and clarify requirements and improve arrangements where necessary.

3) Co-generation Projects: NEMA, in collaboration with ERA and DWRM, should review existing effluent releases and effluent treatment plants at sugar factories/co-generation projects, and clarify requirements and improve arrangements where necessary.

4) Water Supply: Project developers should ensure that water users adversely affected by hydropower projects are provided with a safe, alternative water supply.

5) Water Conflicts: DWRM, in collaboration with ERA, DWRM and other stakeholders, should avoid and minimise conflicts over water resources by proper mapping and engagement of projects and water users along a river, undertake appropriate hydrological assessments prior to project design, consider future water needs, and monitor water quantity and quality to inform future water resources management.

6) Catchment Management: Project developers should develop, implement, and periodically review catchment management plans to adequately address existing and emerging water resources issues in line with the catchment management planning guidelines.

7) Water Source Protection: Project developers should develop, implement, and periodically review water source protection plans in line with the framework and guidelines for water source protection for hydropower plants.

8) Collaboration: ERA should strengthen inter-agency collaboration with DWRM and NEMA, including joint project inspections, to ensure that electricity generation projects avoid and minimise adverse impacts on water resources.

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BIODIVERSITY



Ningu *(Labeo victorianus)*, a fish species found only in the Lake Victoria region and known to have both migratory and resident populations (photo by GET FiT Uganda).

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BIODIVERSITY



Ningu *(Labeo victorianus)*, a fish species found only in the Lake Victoria region and known to have both migratory and resident populations (photo by GET FiT Uganda).

5 BIODIVERSITY

5.1 Introduction

5.1.1 What is Biodiversity?

Biodiversity, also known as biological diversity, is the diversity of species, habitats and ecosystems in the world. This includes species of plants, animals, bacteria and fungi as well as the genetic variation within species. Biodiversity is not distributed evenly across the world. Uganda is known for high levels of biodiversity, including species not found elsewhere, despite the relatively small size of the country.

5.1.2 Uganda's Unique Location and Varied Ecosystems

Uganda has a rarely wide variety of ecosystems resulting in world-class biodiversity. A prime reason is Uganda's location between the East African highlands and the Central African lowland forests. Uganda has important elements of both regions as well as the rich biodiversity that typically develops in transition zones between such regions.

The impressive variation in ecosystems ranges from comprehensive river, wetland and lake ecosystems with biodiversity not found elsewhere, via different forest ecosystems including some of the most biodiversity-rich forests on the continent, savanna ecosystems with large wildlife, arid ecosystems north of the Nile River, to mountain areas with high-altitude ecosystems, including glaciers in the Rwenzori Mountains. The variation in ecosystems also means that a variety of risks to biodiversity needs to be considered when developing Electricity Supply Industry projects as the same type of project may have different impacts in different ecosystems.

5.1.3 Protected and Internationally Recognised Areas

Uganda has approximately 700 protected areas covering 16% of the land and inland water areas (UNEP-WCMC, 2023). Sixteen of these protected areas have international designations.

The overwhelming majority of formally protected areas are forest reserves, many of which have been severely degraded and lost much of the original biodiversity. The ten national parks represent the largest protected areas in the country and harbour some of the most important biodiversity. Table 5-1 lists the number of protected areas by category.

Table 5-1: The number of protected areas in different categories.

Protected area designation	Number	Typical IUCN category	Comments
Forest reserve	661	Not categorised	Widely varying size and condition. Some forest reserves are for commercial plantation forestry rather than biodiversity conservation.
Wildlife reserve	12	III	Relatively large areas typically act as buffer zones of national parks.
National Park	10	II	Usually large areas with a strong degree of protection.
Wildlife sanctuary	7	VI	Typical multiple-use areas.
Community wildlife management area	5	VI	Typical multiple-use areas.

Source: Modified from UNEP-WCMC, 2023.

Uganda has two UNESCO World Heritage Sites of natural heritage recognised for their "outstanding universal values" at the global level: Rwenzori Mountains National Park, and Bwindi Impenetrable National Park. This status is the most prestigious international designation for nature conservation areas. There are also two UNESCO Biosphere Reserves: Queen Elizabeth Biosphere Reserve, and Mount Elgon Biosphere Reserve.[2] Twelve Ramsar wetland sites of international importance have been designated. A total of 50 Key Biodiversity Areas (KBAs) have been designated. Table 5-2 below lists the areas with international designation, several of which have direct or indirect interface with electricity projects.

[2] UNESCO Biosphere Reserves are sites that seek to foster harmony between people and nature for sustainable development through participation in management of these areas that are part of the international Man and the Biosphere (MAB) programme. The UNESCO World Heritage Sites, on the other hand, are designated under the World Heritage Convention due to outstanding universal values to humanity. These natural heritage areas typically need to meet stringent criteria and are managed more strictly as protected areas.

Table 5-2: The protected areas with international designations.

Protected area	No.	Comments
UNESCO World Heritage Sites	2	• Rwenzori Mountains National Park. • Bwindi Impenetrable National Park. The World Heritage Sites overlap with the national parks that both are IUCN category II. Bwindi has parts of the small infrastructure for the Bwindi micro hydropower project shortly inside the national park boundary.
UNESCO Biosphere Reserves	2	• Queen Elizabeth Biosphere Reserve, which overlaps with Queen Elizabeth National Park (IUCN cat. II) and with the Kigezi and Kyambura Wildlife Reserves (IUCN cat. III). • Mount Elgon Biosphere Reserve overlaps with Mount Elgon National Park (IUCN cat. II). Both Biosphere Reserves have been affected by Electricity Supply Industry infrastructure. Queen Elizabeth has a high-voltage transmission line through the national park while Mount Elgon has parts of the infrastructure for the Siti 1 small hydropower project inside its boundary.
Ramsar Sites	12	• Lake Bisina Wetland System, which overlaps with the Lake Bisina Key Biodiversity Area. • Lake George, which partly overlaps with Queen Elizabeth National Park (IUCN cat. II), Biosphere Reserve, and Key Biodiversity Area. • Lake Mburo-Nakivali Wetland System, which overlaps with parts of Lake Mburo National Park, Key Biodiversity Area, and includes Lake Nakivali and areas outside the national park. • Lake Nabugabo Wetland System, which overlaps with the Nabugabo Wetland Key Biodiversity Area. • Lake Nakuwa Wetland System, which includes the Lake Nakuwa Key Biodiversity Area as well as other areas. • Lake Opeta Wetland System, which overlaps partly with the Lake Opeta Key Biodiversity Area. • Lutembe Bay Wetland System, which overlaps with the Lutembe Bay Key Biodiversity Area. • Mabamba Bay Wetland System, which overlaps with the Mabamba Bay Key Biodiversity Area. • Murchison Falls-Albert Delta Wetland System, which overlaps with the larger Murchison Falls National Park and the corresponding Key Biodiversity Area.

Protected area	No.	Comments
		• Nabajjuzi Wetland System, which partly overlaps with the larger Nanajjuzi Wetland Key Biodiversity Area. • Rwenzori Mountains, which overlaps with the Rwenzori Mountains National Park, World Heritage Site and Key Biodiversity Area. • Sango Bay-Musambwa Island-Kagera Wetland System, which overlaps with the Sango Bay Key Biodiversity Area. The Ramsar sites are affected by several human activities and pressures but not primarily from the Electricity Supply Industry at present.
Key Biodiversity Areas	50	The substantial number of Key Biodiversity Areas (KBAs) overlaps with several of the nationally designated protected areas and also the internationally designated areas. Some of the KBAs are outside formally protected areas. The KBAs are affected by several human activities and pressures but not primarily from the Electricity Supply Industry at present.

Sources: Modified from https://whc.unesco.org/en/list/, https://www.unesco.org/en/mab/list?hub=66369, https://www.ramsar.org/country-profile/uganda, and https://www.keybiodiversityareas.org/kba-data.

5.1.4 Ecosystem Services

The wide variety of ecosystems provides different types of ecosystem services that are important for human well-being. Ecosystem services include a range of benefits that people obtain from ecosystems, and these can be categorised into:

- Provisioning services, for example, provision of products like food, freshwater, fish, wood, fibre, fuel/energy, and medicines.
- Regulating services, for example, water purification, pollination, climate regulation, flood regulation, carbon sequestration, and control of pests and diseases.
- Cultural services, for example, non-material benefits such as cultural identity, sense of home, spiritual experience, educational, recreation, and aesthetic values.
- Supporting services, for example, primary production (photosynthesis), nutrient cycling, water cycling, and soil formation.

The importance of ecosystem services in Uganda is underlined by the fact that the backbone of electricity generation, hydropower, relies on water resources as a provisioning service and ecosystems regulate climate and flooding in ways beneficial to hydropower generation.

5.1.5 National and International Legal Frameworks

Important national and international legal frameworks provide minimum standards and guidance for any form of development such as Electricity Supply Industry projects on how to avoid and minimise impacts on important biodiversity as well as for conservation and sustainable use of biodiversity. At national level, these legal frameworks include:

1) Constitution of the Republic of Uganda, 1995, as amended.
2) National Environment Act, 2019.
3) Uganda Wildlife Act, 2019.
4) National Forestry and Tree Planting Act, 2003.
5) Water Act Cap 152 (currently under review).
6) Fisheries and Aquaculture Act, 2022.
7) National Environment (Environmental and Social Assessment) Regulations, 2020.
8) National Environment (Standards for Discharge of Effluent into Water or Land) Regulations, 2020.
9) Water Resources Regulations, 1998.
10) Water (Waste Discharge) Regulations, 1998.

With the National Environment Act, 2019, Section 115, a legal provision for biodiversity offsets was introduced and a separate guideline has since been established for biodiversity offsets (NEMA, 2022). This is particularly relevant when affecting high-value biodiversity.

Uganda has also signed and ratified several international agreements, including:

1) African Convention on the Conservation of Nature and Natural Resources, 1968, revised 2003.

2) Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar), 1971, amended by the 1982 Protocol and the 1987 Amendment to the Convention.
3) UN Convention on Protection of World Cultural and Natural Heritage (World Heritage Convention), 1972.
4) United Nations Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), 1973.
5) Convention on the Conservation of Migratory Species (Bonn Convention), 1979.
6) UN Convention on Biological Diversity (Rio Convention), 1992.
7) Agreement on the Conservation of African-Eurasian Migratory Waterbirds (AEWA), 1995.
8) East African Community Protocol for Sustainable Development of Lake Victoria Basin, 2003.

Multiple instruments have been developed under these agreements and Uganda has undertaken measures to domesticate and implement these, including having multiple areas designated under such agreements (e.g., Ramsar wetland sites, World Heritage Sites). Uganda has also developed plans to translate international agreement into national plans and targets, for instance through the National Biodiversity Strategy and Action Plan II 2015-2025 (NEMA, 2016).

5.2 Driver and Pressures

The main underlying driver is the need for electricity (see Section 3.1.1 above) that results in the construction and operation of generation, transmission and distribution projects and associated infrastructure that exert pressures on biodiversity. Decommissioning is less common but may also result in pressures and impacts. If planned and implemented well, decommissioning may open for restoration of areas towards more natural conditions and hence be positive for biodiversity.

For biodiversity, the Electricity Supply Industry's main pressures typically include:

- Demand for land to install and operate infrastructure, including maintenance of wayleave corridors to prevent establishment of tall trees.
- Improved access resulting from the construction of new roads associated with the Electricity Supply Industry projects.
- The need for water abstraction, particularly for the non-consumptive water use for hydropower generation.
- Reservoir creation and impounding of water to regulate water flow for long-term or short-term storage (hydro-peaking).
- Effluent releases resulting in water quality changes (pollution) during construction activities and operation of generation projects, and waste disposal into water bodies.
- The need for biomass resources in co-generation projects.
- The need for change to clean energy may result, for instance, in the replacement of biomass for institutions or households' energy needs with electricity.

These pressures can lead to changes in the state of the environment that subsequently cause impacts that need to be managed. These cause-effect chains are illustrated in Figure 5-1 below through the DPSIR model, which summarises the main driver, the resulting pressures, the main changes in the state of the environment that may result from the pressures, the subsequent impacts, and potential responses. These elements are discussed further in Sections 5.3, 5.4, and 5.5 below. Some of the water resources issues, waste and pollution, and climate change that can affect biodiversity are also discussed in Sections 4, 8 and 9, respectively.

5.3 State of the Environment

5.3.1 Land Requirements

Generation, transmission and distribution of electricity require land for installation and operation of facilities. Some land may be needed only temporarily during construction while other land areas are required for the long-term operation phase of the facilities.

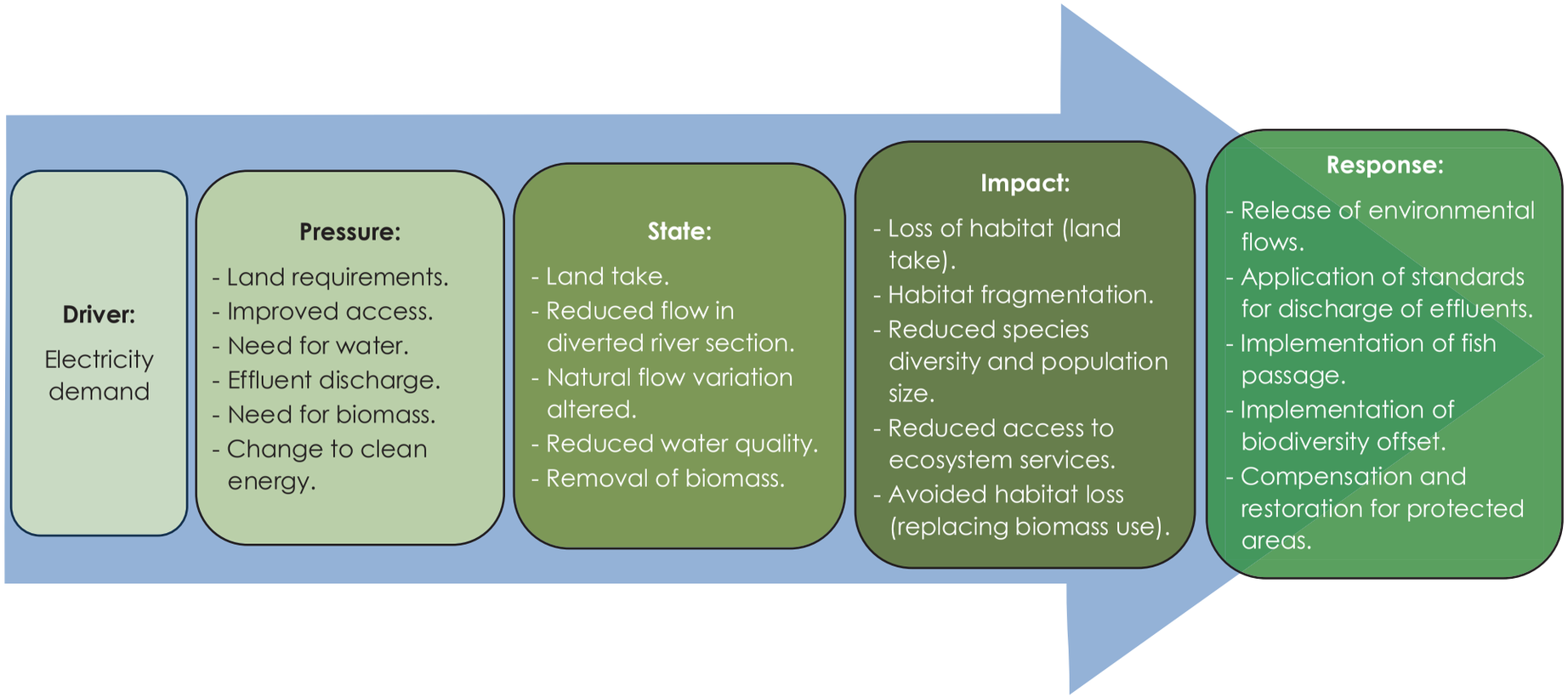


Figure 5-1: Key elements in the DPSIR model summarising the main pressures, states, impacts and responses concerning the Electricity Supply Industry's effects on biodiversity.

Unclassified

Generation projects have a footprint from the installation of physical structures, whether hydropower, thermal, or solar PV. Hydropower projects may also result in the inundation of land areas from dam construction and the establishment of a reservoir. Generation projects in remote areas or in areas with poor access will typically require the construction of new access roads. Improved access to previously poorly accessible areas may enable people to increase the extraction of natural resources in these areas (e.g., harvesting forest resources) or to open up new agricultural areas. Such indirect impacts on land and biodiversity can be important in some projects.

The direct physical land take from transmission and distribution infrastructure is typically limited to land for substations, towers and poles for the lines. However, the wayleave for lines will typically require the removal of any forests, which represents a form of land requirement that is particularly important for transmission lines.

For biodiversity, the change in the state of the environment and associated impacts will typically be most prominent in areas with natural habitats where human activities have not substantially altered ecosystems earlier. Therefore, natural habitats, including protected areas, are described in further detail below.

To contextualise the changes described below it is important also to consider the wider land use and land cover changes in the country that have taken place over time and have been caused by several sectors and factors. As is indicated in Figure 5-2, there have been considerable changes in land use over the past three decades, including loss of woodland areas and tropical high forests as well as an increase in built-up areas, farmlands as well as planted forests.

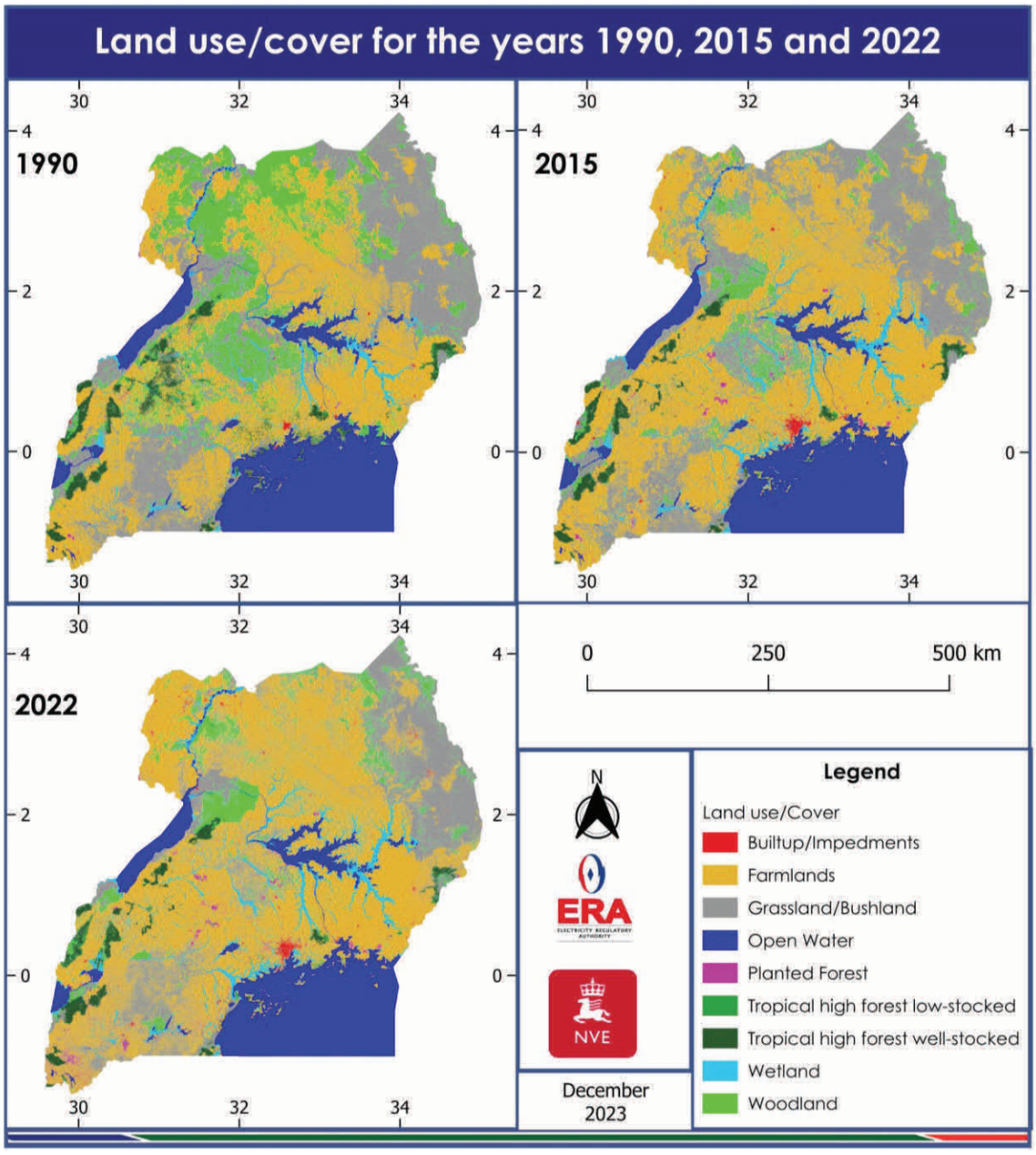


Figure 5-2: Changes in land use and land cover from 1990 to 2015 to 2022.

Land Take in Protected Areas – Existing Infrastructure

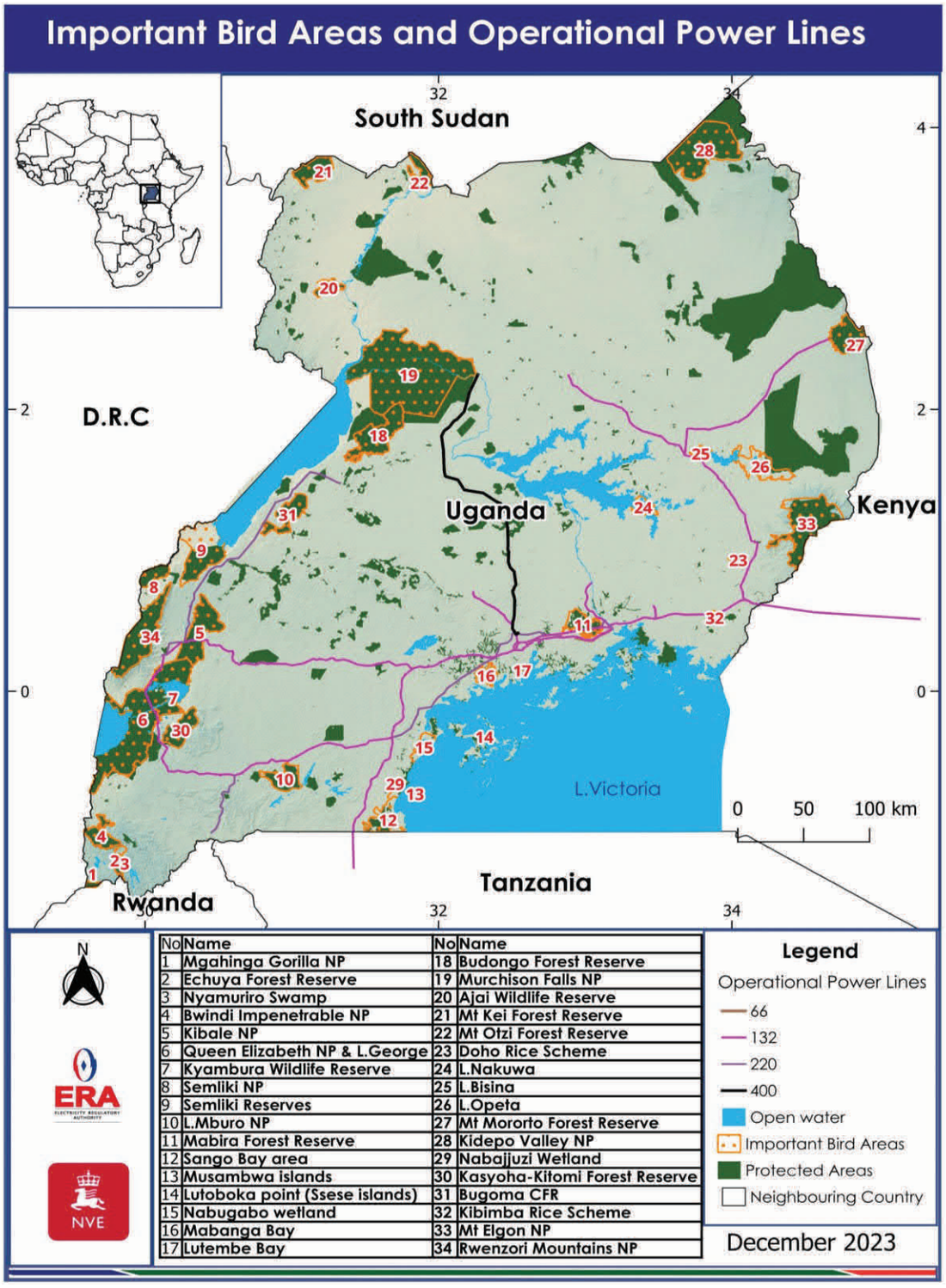
Some of the existing electricity infrastructure affects protected areas directly through land take. There are also indirect impacts where infrastructure is located outside the protected area but may result in improved access to areas near the protected area, which may facilitate encroachment or illegal harvesting (e.g., illegal hunting of wildlife in Murchison Falls and Rwenzori Mountains National Parks).

The overall larger footprint of transmission lines compared with the more localised generation projects means that transmission lines affect more protected areas than generation projects. Figure 5-3 below shows operational high-voltage lines in relation to protected areas and Important Bird and Biodiversity Areas (IBAs). Many forest reserves are affected by transmission lines, partly due to the long distances covered by transmission lines and partly due to the large number of forest reserves. National parks are to a smaller extent affected.

Murchison Falls National Park is affected by the river diversion by the Karuma HPP (see Figure 5-4) and by the Karuma-Olwiyo transmission line corridor along the Karuma-Pakwatch road that goes through the national park for approximately 44 km. The Mbarara South-Nkenda 132 kV line passes through Queen Elizabeth National Park for approximately 48 km (see Figure 5-5).

Mount Elgon National Park is affected by the Siti 1 HPP where the weir, intake, sedimentation basin and parts of the buried headrace pipeline in a corridor of approximately 1.3 km. The very small Bwindi micro hydropower project has infrastructure approximately 100 m inside the Bwindi Impenetrable National Park to provide off-grid supply to the remote Bwindi Community Hospital. The Rwenzori Mountains National Park is an example where a large number of Electricity Supply Industry projects are located near, but not inside, the park (Figure 5-6).

Table 5-3 below summarises the number of protected areas affected directly by Electricity Supply Industry projects. It should be noted that the extent of impacts varies substantially between projects with some affecting only a few acres while others affect several km^2. As discussed in Section 1.3, distribution lines have not been considered in this report and are therefore not reflected in Table 5-3.



No	Name	No	Name
1	Mgahinga Gorilla NP	18	Budongo Forest Reserve
2	Echuya Forest Reserve	19	Murchison Falls NP
3	Nyamuriro Swamp	20	Ajai Wildlife Reserve
4	Bwindi Impenetrable NP	21	Mt Kei Forest Reserve
5	Kibale NP	22	Mt Otzi Forest Reserve
6	Queen Elizabeth NP & L.George	23	Doho Rice Scheme
7	Kyambura Wildlife Reserve	24	L.Nakuwa
8	Semliki NP	25	L.Bisina
9	Semliki Reserves	26	L.Opeta
10	L.Mburo NP	27	Mt Mororto Forest Reserve
11	Mabira Forest Reserve	28	Kidepo Valley NP
12	Sango Bay area	29	Nabajjuzi Wetland
13	Musambwa islands	30	Kasyoha-Kitomi Forest Reserve
14	Lutoboka point (Ssese islands)	31	Bugoma CFR
15	Nabugabo wetland	32	Kibimba Rice Scheme
16	Mabanga Bay	33	Mt Elgon NP
17	Lutembe Bay	34	Rwenzori Mountains NP

Figure 5-3: Protected areas and Important Bird and Biodiversity Areas (IBAs) with operational transmission lines that pass through or near these areas.

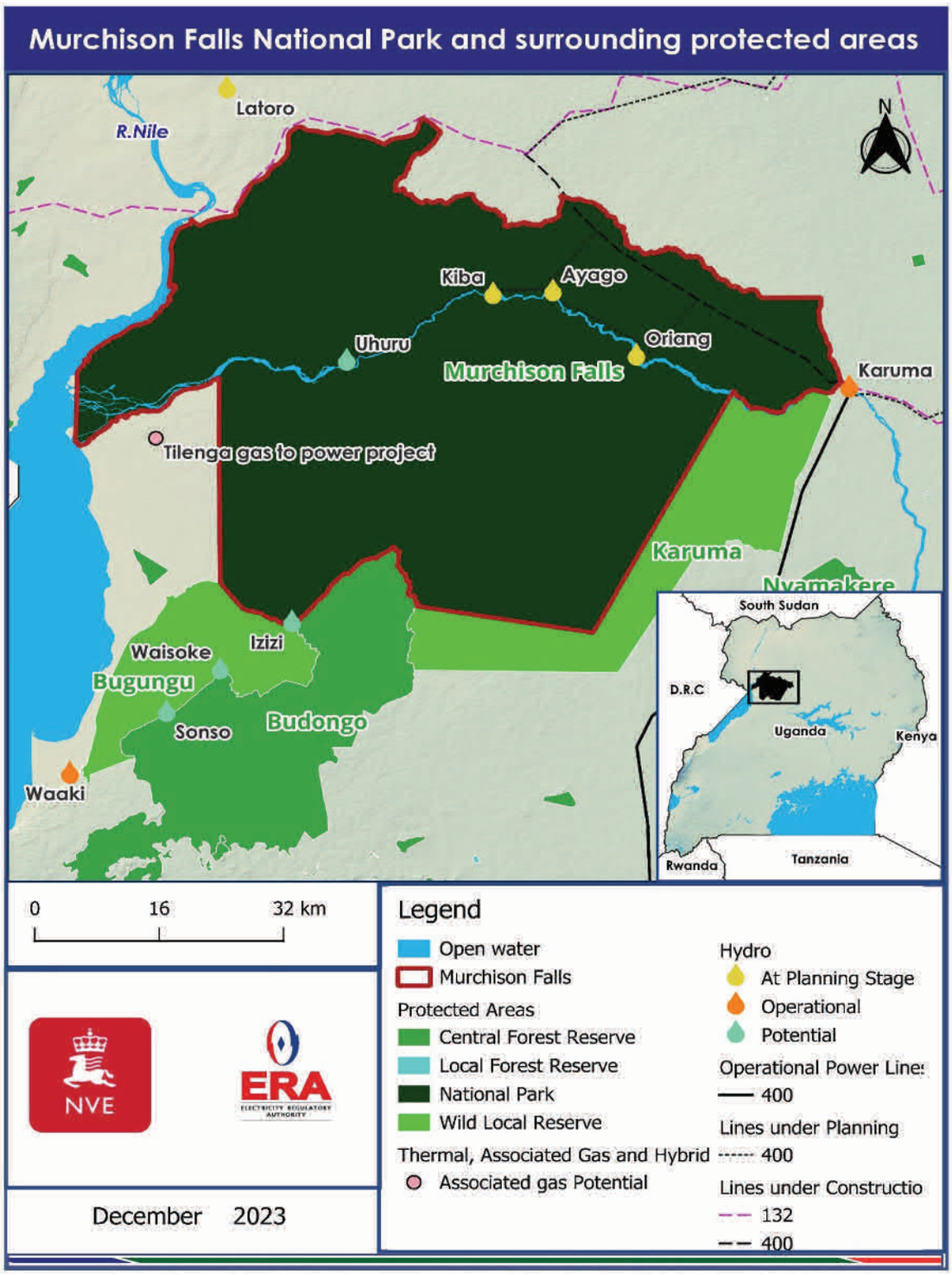


Figure 5-4: Murchison Falls National Park and surrounding protected areas with existing and planned Electricity Supply Industry projects.

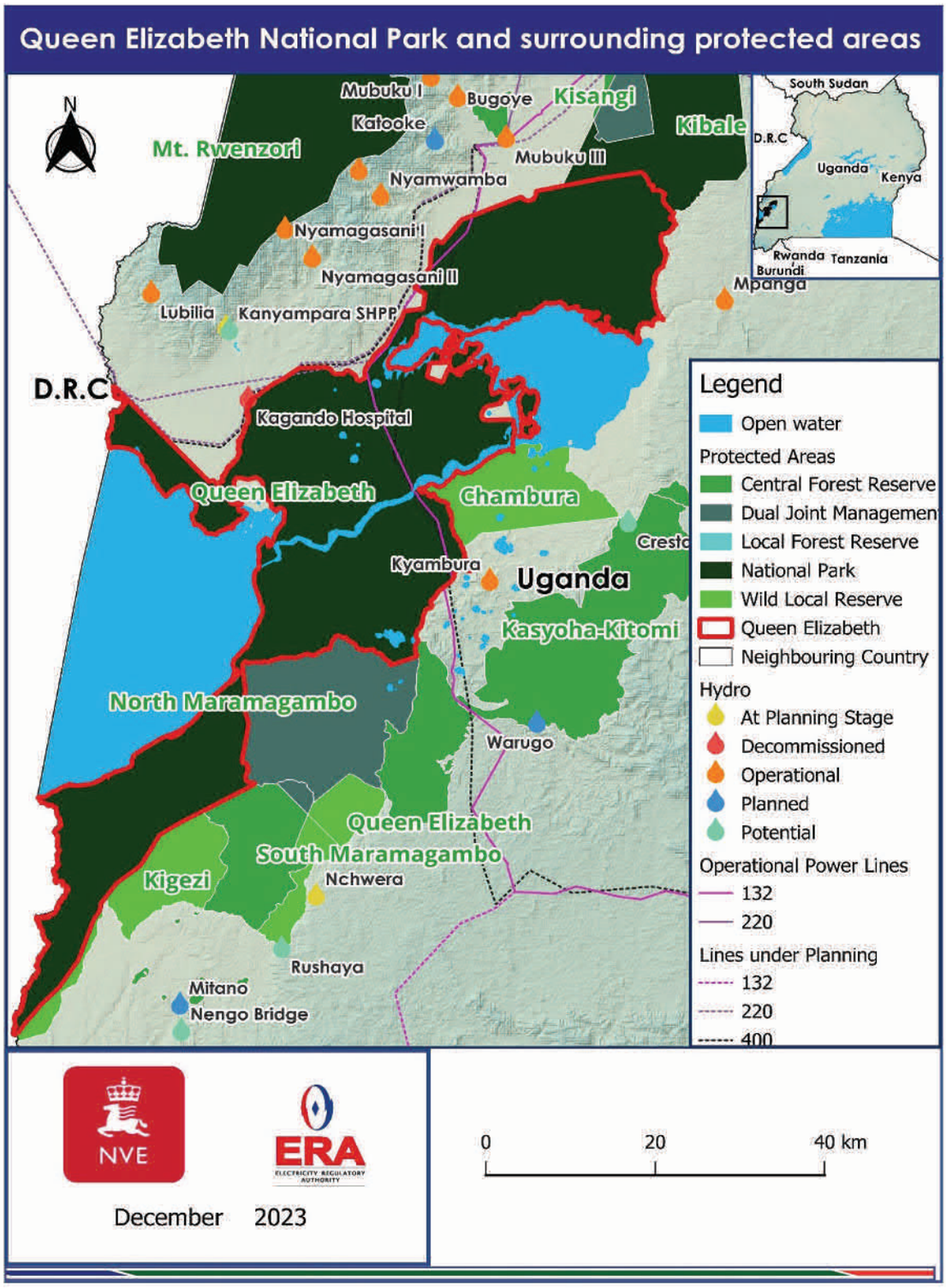


Figure 5-5: Queen Elizabeth National Park and surrounding protected areas with existing and planned Electricity Supply Industry projects indicated.

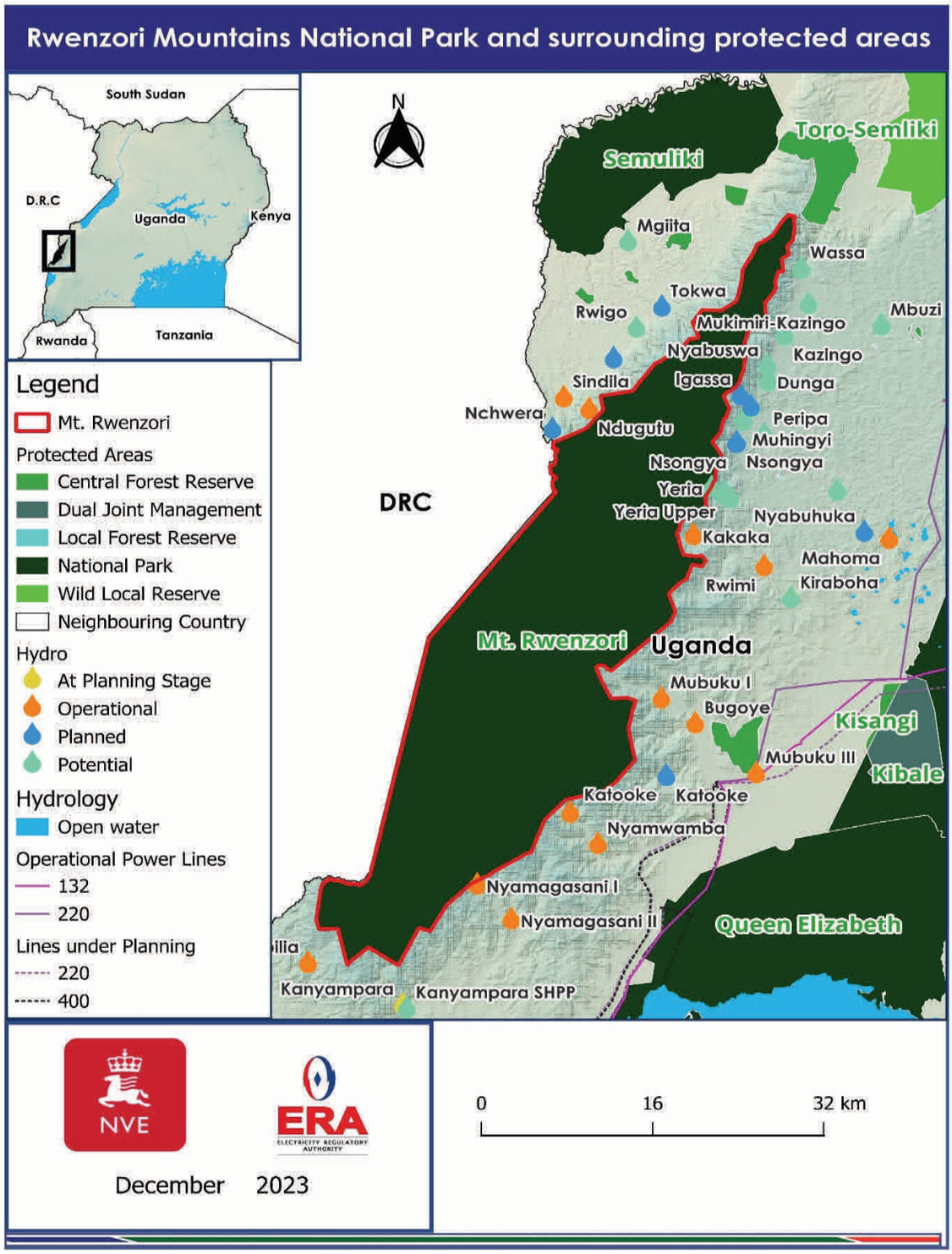


Figure 5-6: Rwenzori Mountains National Park and surrounding Electricity Supply Industry projects implemented or planned.

Table 5-3: The number of protected areas affected by existing generation and transmission projects through land take.

Protected area	Total no. of areas	Protected areas affected by electricity infrastructure		
		Generation	Transmission	Comments
Forest reserve	661	0	Many	
Wildlife reserve	12	1	1	Karuma
National Park[3]	10	4	4	Murchison Falls, Queen Elizabeth, Bwindi, Kibale, Mt Elgon
Wildlife sanctuary	7	1	2	Jinja, Entebbe
Community wildlife management area	5	0	0	

Source: ERA Database, 2023.

The internationally recognised areas overlap substantially with the protected areas. Therefore, some of the internationally recognised areas are affected by the same projects as described above (see Table 5-4).

Table 5-4: The number of internationally recognised areas affected by electricity projects through land take.

International designation	Total no. of areas	Protected areas affected by electricity infrastructure		
		Generation	Transmission	Comments
UNESCO World Heritage Sites	2	1	0	Bwindi
UNESCO Biosphere Reserves	2	2	1	Murchison Falls, Queen Elizabeth, Mt. Elgon
Ramsar Wetland Sites	12	0	0	
Key Biodiversity Areas	50	Several	Several	

Source: ERA Database, 2023.

[3] Rwenzori Mountains National Park is also a UNESCO World Heritage Site and a Ramsar Wetland Site listed in Table 5-4. Queen Elizabeth National Park and Mount Elgon National Park are also UNESCO Biosphere Reserves listed in Table 5-4.

Land take – Protected Areas – Potential Future Infrastructure

There are also proposed electricity projects that may affect protected areas and internationally recognised areas in the future. Among the most prominent are potential large-scale hydropower developments and associated infrastructure such as power lines and access roads inside Murchison Falls National Park. The White Nile River running through Murchison Falls National Park has been identified as a potential location for the Oriang, the Ayago and the Kiba Hydropower Projects, all of which will also require substantial associated infrastructure such as transmission lines and access roads as well as result in inundation of areas along the Nile River. Beyond the project-specific impacts, there will also be cumulative impacts related to hydropower, petroleum production, tourism and other activities in the Murchison Falls National Park, including illegal harvesting of natural resources.

Improved access

Construction and operation of Electricity Supply Industry projects may necessitate opening new access roads, improving existing roads, or opening and maintaining corridors in forest areas for transmission lines. Improved access can enable the transport of natural resources, whether harvested legally or illegally, such as cutting of forest or hunting of wildlife. Improved access may also result in people moving into areas to open new cultivation areas. These unintended impacts from an Electricity Supply Industry project may even affect biodiversity more than the direct impacts from the project.

Few systematic studies appear to have been undertaken of such potential impacts. One study related to small extensions of access roads towards the Rwenzori Mountains National Park for the purpose of hydropower construction revealed substantial levels of illegal harvesting of natural resources, including hunting, inside the national park but the level of illegal activities could not be clearly related to the hydropower projects and the slightly improved access associated with these projects (Bulafu *et al*., 2021).

5.3.2 Reduced Water Flow in Diverted River Section

Water abstraction is required for hydropower generation. This reduces the volume of river water flow substantially between the hydropower project intake and the power station and tailrace where water is returned to the river (see Figure 5-7). As described in Section 4.3.1 above, the length of river section affected and the proportion of water that is removed vary substantially between projects (see also Table 4-1 on pages 107 and 108). Some projects have virtually no diverted river section because water is released from the power station at the foot of the dam very near the intake, while other projects divert most of water away for up to 11 km of the river before the water is returned to the river channel.

For biodiversity dependent upon the natural river flow, the river diversion (water abstraction) will result in adverse impacts. Habitat characteristics change, for instance reduced water depth, reduced water speed, and less available riverbed habitat due to reduced flow. For more information about reduced river flow, see Section 4.3.1 above. Riverbanks and biodiversity near the diverted river section may also be affected by reduced flow that lowers the groundwater level near the river.



Figure 5-7: Minimum flow in parts of the 4.3 km diverted river section at Nyamagasani 2 Hydropower Plant, Kasese District, illustrating the reduction in aquatic habitat as most of the water is used for power production. The headrace canal is visible on the right riverbank (photo by GET FiT Uganda).

5.3.3 Changes in Natural Flow Regimes

Hydropower can substantially modify river ecosystems also by altering the pattern and timing of river flow in ways that the ecosystems are not adapted to. Such changes can also affect water quality. Water temperature may be reduced downstream of a dam due to reservoir releases from deep areas of the reservoir or due to a long pipeline where cool water from higher elevation in a mountain area is released further downstream from the tailrace without being naturally warmed in the river between the intake and the tailrace.

The connectivity between the river and the surrounding areas (e.g., wetlands, floodplains, riverine forest) may be altered both along the reservoir where water levels are raised, or downstream of the tailrace

where the flow regime is altered. These changes may also affect water users such as domestic water use, abstraction for irrigation, or abstraction for other activities.

From river environment to lake-like environment

The construction of dams for establishment of hydropower reservoirs typically inundates sections of the flowing rivers upstream of the dam and convert these river sections into a more lake-like environment (see Figure 5-8). Such change in the environmental conditions typically displaces terrestrial species of plants and animals that originally occupied the area. The change also affects aquatic species composition in the river system away from species that thrive under flowing river conditions to species that thrive under more lake-like conditions after the inundation.

While many Ugandan hydropower projects do not inundate significant areas (e.g., Nyamagasani 1, Nyamagasani 2, and Nyamwamba), hydropower projects having such impacts include the Victoria Nile hydropower projects (Bujagali, Isimba, and Karuma) and some of the smaller hydropower projects (e.g., Nyagak 1, Rwimi, Kyambura, and Kikagati). Figure 5-8 shows examples of projects with and without inundation. Figure 4-5 on page 114 also illustrates the change for the larger Isimba Hydropower Project on the Victoria Nile.

Short-term and long-term storage – opposite effects on flows

Large reservoirs can store water from one period to another. Such storage may be short-term, for instance, storing water in a reservoir during the night or daytime when electricity demand is lower in order to generate more electricity during morning and evening peak demand periods when more water is needed for power generation. This mode of operation may be referred to as hydro-peaking, which results in unnaturally large flow variations over short periods such as the 24 hours day/night cycle.



Figure 5-8: Upper photo shows a project with no inundation (Nyamagasani 1 HPP) and lower photo with inundation, Rwimi HPP (photos by GET FiT Uganda).

Very few hydropower projects in Uganda undertake hydropeaking operations, more than 30 of the 36 operational hydropower projects simply use the existing river flow at any time to generate power (see Table 4-1 above). The water volume that comes to the dam or weir equals the volume that is released downstream of the power station from the tailrace, there is no storage from one period to another.

There is an element of hydro-peaking for the Victoria Nile cascade with ramping up and down particularly of the Kiira hydropower plant in Jinja

to meet the daily variation in electricity demand. The downstream projects at Bujagali and Isimba will typically respond to the increased inflow from the Kiira release by increasing output as well.

The Isimba HPP and reservoir on the Victoria Nile has the capacity to function as short-term storage for peaking, but only for approximately 3 hours. In practice, Isimba is typically operated as a run-of-river project where the volume of water coming into the reservoir is equal to the volume of water going through the turbines and released downstream.

Longer-term water storage, for instance, seasonal storage or multi-year storage of water in reservoirs, tends to store water during high flow periods (rainy season) for use during lower flow periods (dry season). As opposed to hydro-peaking, which creates short-term, unnatural flow variation (see Figure 5-9), the long-term storage has the opposite effect, namely to reduce variation over time by increasing flow (reservoir releases) during the drier low flow season and reducing flow (reservoir storage) during the wetter high flow season (see Figure 5-10).

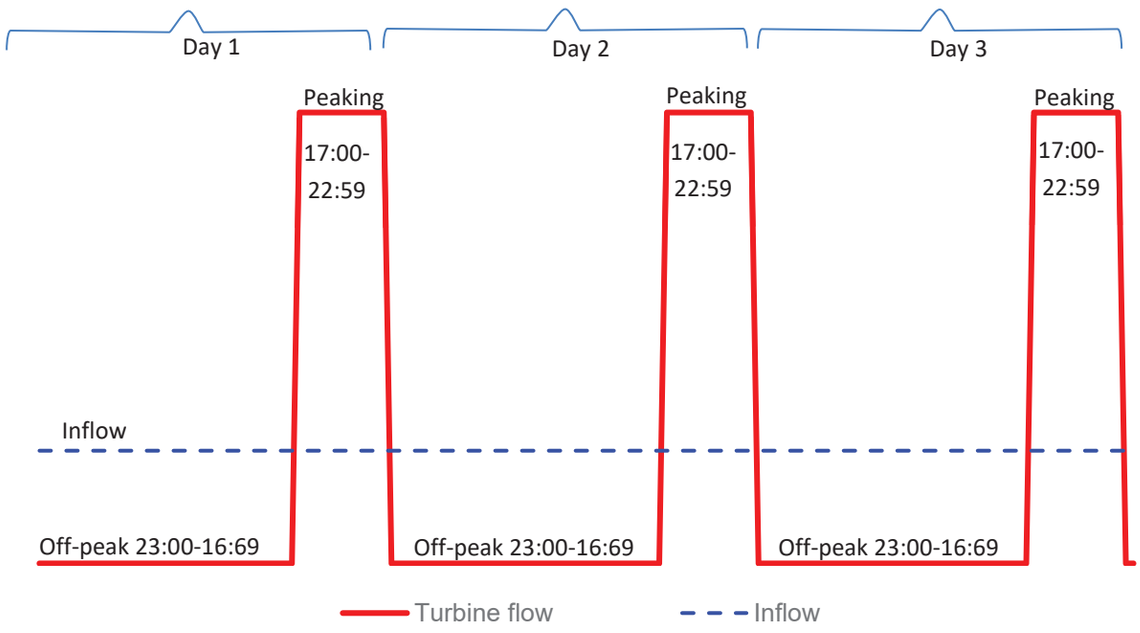


Figure 5-9: Illustration of river flow upstream of a hydropower project (inflow) and river flow downstream of the same hydropower project (turbine flow) undertaking daily hydro-peaking for six hours in the evening (17:00-22:59).

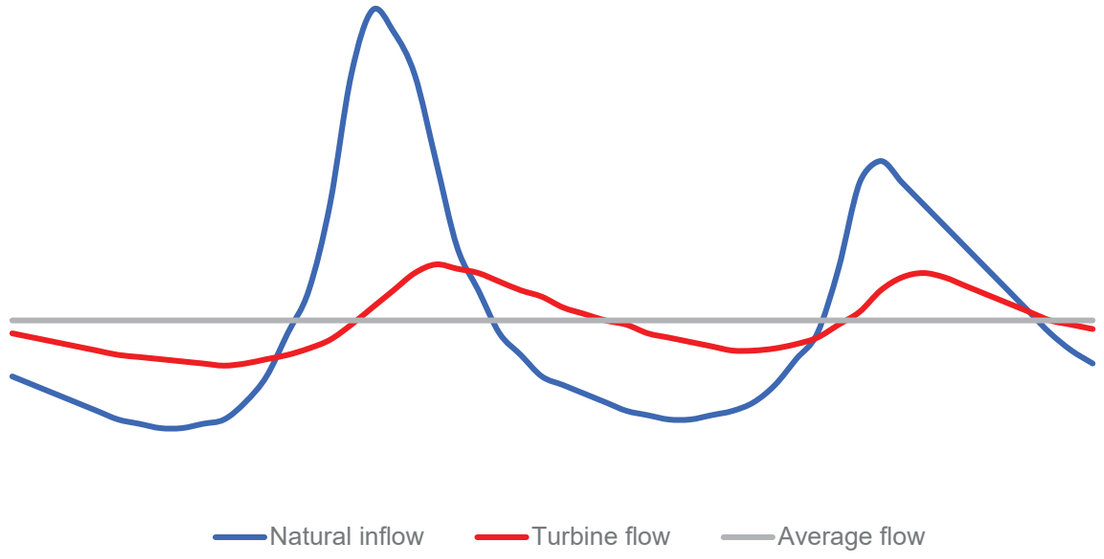


Figure 5-10: Illustration of river flow upstream of a hydropower project (inflow) and river flow downstream of the same hydropower project (turbine flow) across a full year with two rainy seasons where water is stored in a large reservoir from the rainy season to be gradually released in the dry season.

Hydropower projects in Uganda do not have sufficient storage capacity to undertake such alteration of flows with the exception of Nalubaale and Kiira, which can be used to increase or reduce outflow from the extremely large reservoir that Lake Victoria represents. The size of Lake Victoria means this can be considered a multi-year storage reservoir. In effect, Lake Victoria also acts as a large-scale storage for hydropower projects further downstream on the Victoria Nile (Bujagali, Isimba, and Karuma). The operation of this "reservoir" is, however, constrained by international agreements with downstream countries that require the releases to follow the so-called "agreed curve" that specifies a certain water release depending on the lake level.

Transfers between rivers

Hydropower projects may have the intake in one river and then transfer the water through the canal and pipe to a power station that releases the water into a different river, such as at the Ndugutu Hydropower Project releasing water into the neighbouring Sindila River. This can permanently reduce flow in the river where abstraction takes place and permanently increase flow in the receiving river. Species in the river can also be transferred with the water and thereby be introduced to a new river system. Such transfer can be from one river to another within a river basin or it can be between different river basins, the latter which will typically result in greater changes and impacts.

One of the small hydropower projects in Uganda transfers water from one river (Ndugutu) to another (Sindila) but at a very local scale and within the same main river system (see Figure 5-11). Because the rivers are naturally connected only 4 km downstream of where water from Ndugutu is released into Sindila, no introductions or other substantial biodiversity impacts are likely caused by this small transfer schemes. People living in the area and using the rivers will, however, notice changes in river flows upstream of the confluence between the two rivers that is located 4 km downstream of the release point in Sindila River. This 4 km section of Sindila River carries water from both Ndugutu and Sindila.

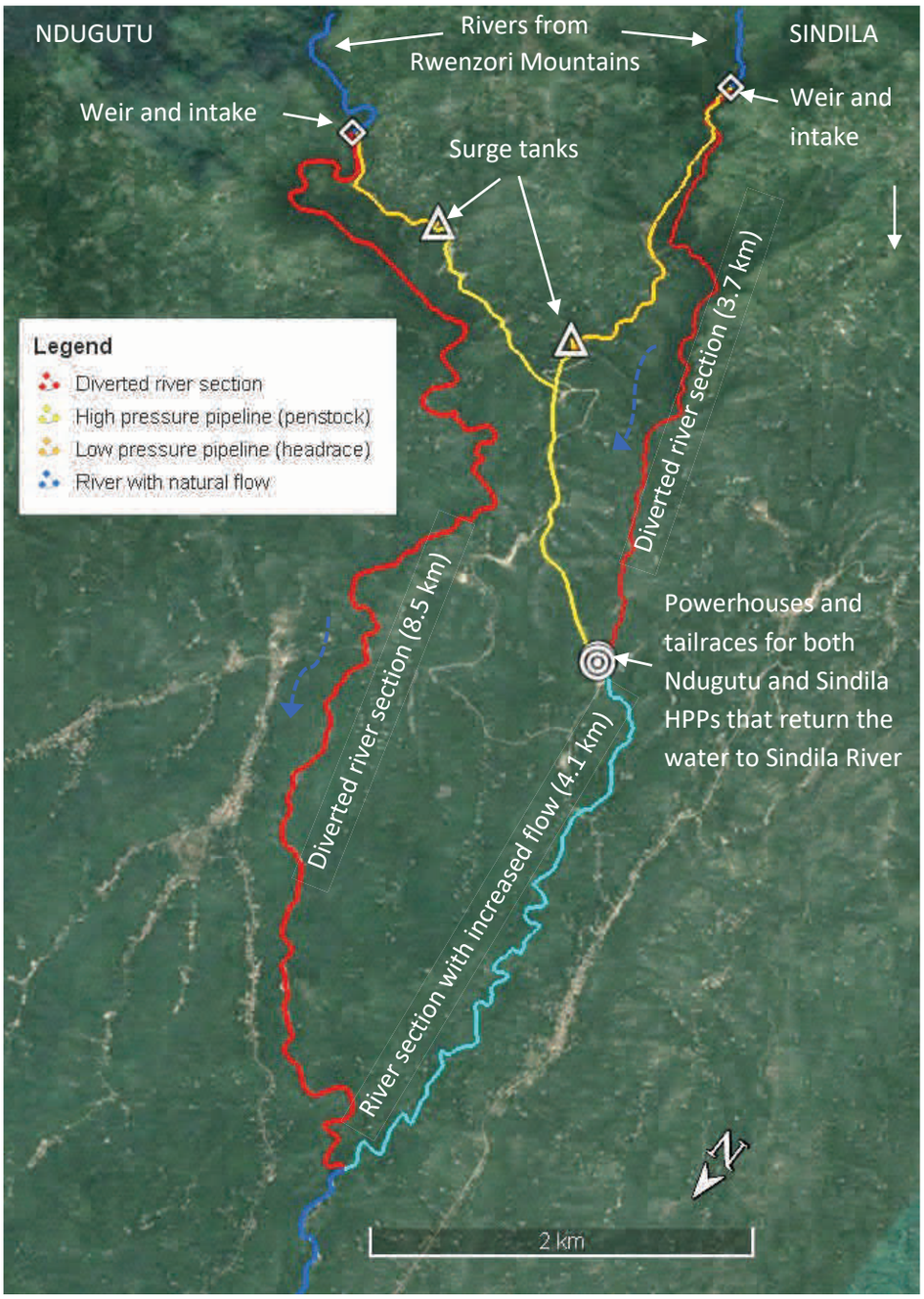


Figure 5-11: Illustration of river transfer associated with the Ndugutu hydropower project, which transfers water from Ndugutu River to Sindila River (modified from Google Earth).

5.3.4 Reduced Water Quality

Hydropower projects can result in changes to water quality (turbidity, temperature, oxygen, etc.) during construction and operation as discussed in Section 4.3.3 above. These water quality changes may also affect biodiversity. For instance, increased sediment load may smother habitats and reduce the presence of macro-invertebrates such as insects, which reduce availability of food for fish and birds. Sediment flushing from a dam can result in large volumes of sediments suddenly being released downstream, which has resulted in mass fish death downstream in at least one of the hydropower projects in Uganda.

5.3.5 Removal of Biomass

In Uganda, biomass is not grown specifically as fuel for electricity production but biomass as by-products from sugar production (bagasse) and forestry operations (forest residue) are used to produce electricity in co-generation plants. Changes in biodiversity are therefore indirect through the biomass supply chain and cannot be solely attributed to the Electricity Supply Industry. Other agricultural waste as well as other waste may be used for electricity generation in the future.

There are substantial areas converted to sugarcane cultivation and the sugar cane production has increased almost four times from 1.5 million metric tons in 2000 to 5.8 million metric tons in 2020 and land under sugar cane increased from approximately 20,000 ha to over 81,000 ha over than period (Mbowa *et al.*, 2023). The number of sugarcane mills and co-generation plants also grew substantially over this period.

Many of the areas were originally forest areas even if many of those areas were first cleared for smallholder cultivation and later converted to sugarcane fields. The displacement of smallholder subsistence farming by larger-scale sugarcane cultivation may result in additional forest or wetland areas being converted to agricultural areas for food crop cultivation. Similarly, forest plantations may displace farming activities and result in the clearing of natural forest areas for subsistence farming. Data on the extent to which sugarcane production and forestry contribute to clearing of biodiversity rich areas such as forests or wetlands were not found for this report.

The extent to which electricity generation based on biomass is resulting in additional removal of forest, wetlands or other biomass through the supply chain is difficult to estimate and beyond the scope of this report.

5.4 Impacts

5.4.1 Loss of Habitat

Land requirements for all Electricity Supply Industry projects, improved access, and removal of biomass for co-generation projects result in the loss of or change in habitats such as forests. Water abstraction for hydropower resulting in reduced river flow and reduced water quality from pollution will reduce or change habitat availability and quality for aquatic life. Loss of habitat is likely the most important adverse impacts on biodiversity, whether for terrestrial or aquatic habitats. This may be caused by inundation of land areas due to dam construction, loss of areas from construction of infrastructure, or drying out of river areas due to river diversion.

Changes in habitat characteristics such as reduction in river flow rather than complete drying out, increased noise and disturbance, etc., rather than complete loss of a habitat, can alter conditions under which species interact with each other, and these changes may result in changes in competitive relationships between species or predation. Such changes may cause loss of individuals and reduction in population size. For instance, reduced river flow (rather than complete drying out of a river section) will reduce water depth and this can increase predation risks on fish from birds and humans.

In some unique cases, there may be highly specialised species adapted to habitats highly dependent upon the natural levels of river flow. One such unique habitat that is known to contain unique species if the conditions are right, is spray zone areas, which at times are found at waterfalls where vapour sprays are formed during high flow levels and create a unique microclimate. Water diversion for hydropower has in some cases (e.g., Lower Kihansi Hydropower Project, Tanzania) been shown to result in serious impacts on unique ecosystems and species

including global species extinction in the wild (Channing *et al*., 2006). Unless carefully planned and implemented, hydropower projects can affect unique biodiversity such as vapour spray zones that at times provide habitat for rare or endangered species. Diverting water for power generation can adversely affect the unique spray zone and biodiversity by reducing river flow and spray generated (see Figure 5-12).

ESI has registered at least one significant mass death event of fish immediately downstream of a hydropower dam during sediment flushing. In this case, the plant operator undertook dam flushing in February (dry/low flow season), a period in which the natural flow in the river is significantly reduced and the sediment load in the water is low.

During this period, aquatic systems are naturally not adapted to receiving high sediment loads. The highest natural sediment loads occur during floods and high flows and the aquatic ecosystem is better adapted to such conditions during the rainy season. Flushing sediments during a low flow period increases the sediment load to levels much higher than the natural concentration and can result in stress or mass death event of fish and other aquatic life (see Figure 5-13).



Figure 5-12: Spray zones may be hotspots for unique biodiversity, here illustrated by the spray zone around Nkusi falls prior to river diversion. Inset photo showing section of spray zone from above (photos by GET FiT Uganda).



Figure 5-13: Sediment flushing from bottom gate at a hydropower dam releasing large volumes of sediment downstream with adverse impacts (photo by Ziba Limited).

5.4.2 Habitat Fragmentation

Infrastructure can split living areas for species into separate areas and thereby reduce available habitats as well as reduce migration of species between areas. This may occur due to the establishment of physical barriers (e.g., dam) or due to presence of infrastructure or activities that scare species sensitive to the infrastructure and disturbance away (see also Section 5.4.3 below regarding fish migration).

Cutting of a wayleave corridor for a transmission line through a closed forest is a typical example of habitat fragmentation for some species that only inhabit closed forest and will not move into open areas such as the wayleave corridor. These impacts may be worsened by edge effects after opening up a forest, for instance, due to changes in microclimate, changes in light, or intrusion of invasive alien species. Several transmission lines go through forest reserves, national parks with closed forests, or other

forest areas. These transmission lines may have contributed to fragmentation even if the lines in some cases follow existing roads that had already caused a certain level of fragmentation.

The operation of transmission and distribution lines typically results in bird collisions or electrocution of birds, especially in protected areas with rich bird life or if the lines are placed in locations of the landscape where birds typically will fly.

Given the moderate size of solar PV plants in Uganda combined with the flexibility in locating such plants, there will unlikely be substantial fragmentation of wildlife habitats. At the same time, there is potential to combine solar PV plants with livestock activities such as grazing.

5.4.3 Dams as Barriers to Fish Migration

Upstream Migration

One important example of habitat fragmentation and loss of available habitat is the construction of dams and weirs for hydropower that can block the upstream migration of fish and other species living in rivers, thereby damaging the connectivity between aquatic habitats. Some fish species need to migrate to find suitable spawning areas or nursery areas for juvenile fish. Dams blocking such migration can have substantial adverse impacts.

The extent to which a hydropower project results in fragmentation of the aquatic habitats varies substantially. A review for this report indicated that most of hydropower projects in Uganda have likely not contributed significantly to the fragmentation of aquatic habitats by blocking important fish migration. Some projects likely have blocked fish migration and cause fragmentation, while other rivers have not been studied in terms of fish migration and will require further surveys to establish whether existing projects or proposed future projects are likely to block important fish migration routes or not.

Table 5-5 below summarises a review of fragmentation risks from existing hydropower projects in Uganda, including an overall assessment of several river systems. Before concluding on the risk of creating a barrier

through dam construction and potentially needing to implement a fish passage to enable migration beyond the dam, it is important to consider whether there are existing natural or man-made barriers (e.g., another dam for hydropower or water supply) on the river. Depending on their location, such barriers may mean that further fragmentation by dam construction is unlikely and hence fish passage may not be a well justified requirement for the hydropower project.

Interestingly, the review indicated that the large number of hydropower projects in western Uganda within the Lakes George and Edward system (see Figure 5-14) has had a limited fragmentation impact. Due to the steep mountain terrain near many of the projects, the rivers are naturally fragmented due to waterfalls acting as a natural barrier to upstream fish migration. Adding a dam barrier in such steep areas may not add significant fragmentation impacts, unlike adding a dam barrier in more flat terrain without existing barriers. Note that the Ishasha HPP south of Lake Edward is not shown on the map and no projects on the DRC side of the international boundary have been considered.

Table 5-5 also considers that the Victoria Nile system may be most affected by dam barriers. Other rivers have been poorly studied (e.g., the Achwa river system connected to the Albert Nile) and would benefit from further mapping of fish and natural barriers before concluding on the extent of fish migration and the measures required to minimise negative impacts.

Table 5-5: Extent of fragmentation based on initial assessment of the introduction of barriers to upstream fish migration at operational hydropower projects.

Lake/river system	River	Projects	Potential fragmentation
Nile River between Lake Victoria and Lake Kyoga, including the lakes	Victoria Nile	Nalubaale Kiira Bujagali Isimba	Moderate to substantial
Nile River and Lake Kyoga system	Kyoga Nile	Karuma*	Limited to moderate
Lake Victoria and inflowing rivers	Kagera	Kikagati*	Moderate
Lakes Edward and George system	Rwimi	Kakaka Rwimi	Limited
	Mubuku	Mubuku 1 Mubuku 2 Mubuku 3	
	Nyamwamba	Nyamwamba 2 Nyamwamba 1	
	Nyamagasani	Nyamagasani 1 Nyamagasani 2*	
	Lubilia	Lubilia**	
	Mahoma	Mahoma	
	Mpanga	Mpanga	
	Kyambura	Kyambura	
	Ishasha	Ishasha	
Lake Albert and inflowing rivers	Nkusi	Bukinda Nkusi	Minimal to none
	Wambabya	Kabalega	
	Waki	Waki	
	Sindila / Ndugutu	Sindila Ndugutu	
Albert Nile (Lake Albert to the border with South Sudan) and tributaries	Nyagak	Nyagak 1 Nyagak 3	Moderate
	Achwa	Achwa 1 Achwa 2	

Lake/river system	River	Projects	Potential fragmentation
Largely isolated river systems	Maziba	Muvumbe	Minimal to none
	Siti / Nyalit	Siti 1 Siti 2	Minimal to none

* Fish passage constructed. ** Fish passage constructed but later decommissioned.
Source: ERA Database, 2023.



Figure 5-14: Lakes Edward-George system with inflowing rivers that have operational hydropower projects in the northern part (modified from Google Earth).

Four (4) out of 33 hydropower projects with an installed capacity above 1 MW have constructed upstream fish passages (Karuma, Kikagati, Nyamagasani 2, Lubilia). One of these passages (Lubilia) has been decommissioned as it was considered neither ecologically justified due to the presence of a natural barrier to upstream fish migration immediately downstream of the dam nor functional the way it was designed and constructed.

For many of the other 29 hydropower projects above 1 MW, there are natural barriers to upstream fish migration identified such that a hydropower project does not add any significant new barrier that would prevent fish migration. There are, however, multiple rivers where clear documentation on the presence or absence of natural barriers does not exist. This report estimates that there are approximately 15 rivers/ hydropower sites with natural barriers and approximately 12 rivers/ hydropower sites where potentially a fish passage should be considered but is not in place.

Several of these rivers are part of the larger lake-river ecosystems where fish populations requiring access to rivers to maintain their populations can choose between different in-flowing rivers. When hydropower projects are developed on multiple rivers around a lake, there may be cumulative fragmentation impacts from multiple hydropower projects in such river systems. The two most affected lake-river systems in Uganda are the Victoria Nile system between Lake Victoria and Lake Kyoga with four large hydropower projects as well as the Lakes Edward and George system which has numerous inflowing rivers and a total of twelve small hydropower projects on eight rivers in Uganda (Ishasha, Kyambura, Lubilia, Nyamagasani, Nyamwamba, Mubuku, Rwimi, and Mpanga Rivers) on the transboundary system shared with the DRC.

Homing behaviour of migrating fish, that is, the extent to which fish return to the same river they were born to spawn and reproduce themselves, is one multiple aspects of fish migration in Uganda poorly known.

Downstream Migration

Downstream migration of fish and other aquatic organisms can be affected by hydropower projects as most of the water, typically more than 90% during normal flow conditions, go through the waterway and turbines rather than along the natural river. Typically, most of the fish follow the dominant flow and therefore also go through the turbines. Fish mortality during turbine passage can be very high but varies with factors such as turbine type, turbine specifications, head (elevation difference), fish species, and size of the fish. For instance, turbine passage of fish through Pelton turbines will typically result in extremely high mortality,

Francis turbines typically have intermediate mortality, while turbine passage through a low-head, large size Kaplan turbine is likely substantially smaller but there can be considerable variation also for Kaplan turbines depending on project-specific conditions.

A recently initiated and still ongoing fish monitoring programme at the Kikagati Hydropower Project, Kagera River, is providing very interesting datasets for upstream and downstream fish migration, including timing and success of migration that may inform future fish passage designs and hydropower plant operational strategies. The monitoring also covers mortality during downstream turbine passage for the low-head, large size Kaplan turbines at this power plant. These early data are still being analysed but will before the next ESSOER likely provide unique insights and be the first of its kind in Uganda and East Africa.

5.4.4 Invasive Alien Species

Uganda has several highly problematic invasive alien species, for instance fish species and aquatic weeds, but these have typically been introduced due to other projects than Electricity Supply Industry projects. The Electricity Supply Industry is instead affected by such invasive alien species and in some instances inadvertently contribute to further spreading of such species within the country. The invasive alien species can result in loss of native biodiversity or suppress agricultural crops or grasses and herbs used for livestock grazing. Once introduced and established, it is often practically impossible to eradicate the introduced alien species and long-term adverse biodiversity as well as large costs due to losses and invasive alien species control are inevitable.

The highly problematic, introduced water hyacinth (*Eichhornia crassipes*) proliferated substantially from the 1980s and have infested the main water bodies in Uganda. Massive resources have been spent on trying to control this species biologically, chemically, or mechanically, particularly in Lake Victoria (Wanda *et al*., 2015). This species causes substantial adverse impacts on ecosystems and human activities, including fishing, transportation, and reduce water quality.

Several hydropower projects are also adversely affected by the water hyacinth, which accumulates at water intakes and can block the intake trash racks and thereby preventing water abstraction for power generation unless regularly removed and disposed. Some hydropower projects, for instance Nalubaale in Jinja, spend substantial resources on mechanical removal of the species to ensure continued, stable operation and power generation at the Nalubaale-Kiira complex and downstream plants that rely on water from Nalubaale and Kiira.

While fish species do not appear to have been introduced due to hydropower projects, the establishment of hydropower reservoirs may favour introduced fish species that prefer lake-like environments over river environments.

Where Electricity Supply Industry projects involve earthmoving activities, exposed soils may be colonised by seeds in the soil or spread from the surroundings, for instance by water, air, or with materials transported to the site. Exposed soils may therefore be at risk of colonisation by invasive plant species already present in the area. When soils, construction materials or machinery are transported to an Electricity Supply Industry project from different areas, which is common particularly during construction, there are risks of introducing or spreading invasive alien species.

Where natural vegetation needs to be removed for an Electricity Supply Industry project, the modified habitat may be more favourable for invasive species. For instance, clearing of forest for transmission lines may facilitate the expansion of the invasive alien Common Lantana (*Lantana camara*). Such vegetation clearing, potentially combined with introducing seeds with construction materials, can also be an entry point for the invasive species into protected areas such as national parks and forest reserves as well as result in spreading to agricultural areas or grazing areas to the detriment of crop production or livestock grazing.

5.4.5 Reduced Species Diversity and Populations

The habitat loss, habitat fragmentation and invasive alien species described above will typically result in a reduction in the population sizes

of native species and may also result in the local disappearance of certain species. Species that are very sensitive to human disturbance or species that require large areas to survive will often be most vulnerable. Fish species that depend on migration and have their migration routes blocked by dams will also be vulnerable.

5.4.6 Reduced Access to Ecosystem Services

Where people rely on the natural resources and biodiversity that is adversely affected by Electricity Supply Industry projects, the provision of ecosystem services will also be adversely affected and may impact local people's livelihoods.

5.4.7 Avoided Habitat Loss

Biomass has been and remains the dominant source of energy. The gradual introduction of electricity as replacement for biomass, particularly for cooking, can avoid habitat loss that is caused by the need for biomass for cooking. Such transformation from the dominant, current role of biomass will inevitably take considerable time. At the same time, the large volume of biomass currently used for cooking illustrates the large potential reduction in pressure for biomass if the transition away from biomass energy can be ensured.

5.5 Responses

Lead agencies NEMA and DWRM have developed regulations and approval procedures that define conditions and requirements to avoid and minimise impacts on biodiversity. Approval conditions typically include responses to address water quality impacts and ensure eflow releases to protect aquatic biodiversity that is particularly affected by hydropower projects, including the river diversion that results in reduced river flow and habitat availability.

As described in Section 4.5 above, hydropower approvals is typically conditional on the continuous release of a project-specific environmental flow from the dam or weir. Important problems have been observed regarding this important measure (e.g., inadequate releases of

eflow, and missing documentation of eflow releases), hence the recommendations on environmental flow in Section 5.6 below. Impacts from effluents and pollution are typically managed through requirements to prevent pollution in line with existing regulations, see Section 4.5 above for more information.

For terrestrial biodiversity, careful considerations are required for biodiversity-rich areas where adverse impacts should be avoided as far as possible, as was the case with the proposed Kakaka Hydropower Project where initial plans involved locating the intake and upper waterway inside the Rwenzori Mountains National Park (also a World Heritage Site and a Ramsar site). This was avoided by relocating the intake and upper waterway outside the National Park boundary (also outside the World Heritage Site and Ramsar site), after which the project was approved and implemented.

Where Electricity Supply Industry projects cannot avoid affecting protected areas such as national parks, wildlife reserves or forest reserves, the management authorities (UWA and NFA) will define conditions and requirements and their respective legal frameworks provide for certain procedures to be followed and requirements to be met. These responses may include biodiversity offsets that have been introduced under the National Environment Act, 2019, as a measure that can be required to avoid loss of biodiversity.

Offsets have been implemented as compensatory measures for some hydropower projects, for instance at the Siti 1 Hydropower Project to compensate for loss of trees inside Mount Elgon National Park, and for the Bujagali-Kalagala offset on the Victoria Nile to compensate for loss of river rapids following inundation and conversion of fast flowing river sections to a lake-like environment in respect of the Bujagali hydropower project. As for many other measures, offsets require close follow-up to ensure the offset provides the intended biodiversity benefits for as long as the adverse impacts the offset compensates for exist.

UETCL is implementing a biodiversity offset programme under the the Kole-Gulu-Nebbi-Arua transmission and associated substation project. The offset is implemented through the restoration of degraded sections

within eight (8) Central Forest Reserves and six (6) Local Forest Reserves within the project area. A total of 1,300 hectares within the Central Forest Reserves and 81 hectares within Local Forest Reserves will be restored through biodiversity offset.

To avoid and minimise impacts on fish migration, the NEMA approvals for several projects have included requirements to construct fish passage to avoid blocking upstream fish migration. Four projects have constructed such passages, namely Kikagati, Karuma, Nyamagasani 2 and Lubilia (see Figures 5-15 and 5-16).

ERA has observed hydropower projects where the EIA approval conditions specify a requirement to construct a fish passage, typically because this was a recommendation in the Environmental Impact Assessment for the hydropower project in question. Observations by ERA during monitoring visits, have identified natural barriers to fish migration along the same rivers near some of these hydropower projects, which means there was no ecological justification for a fish passage at the hydropower projects in question.

Such requirements for fish passage result in additional costs and practical challenges for project owners both during construction and operation. These examples of inadequately researched EIA recommendations and subsequent EIA requirements in permits, illustrate the need for developers to contract highly competent EIA consultants with specific understanding of hydropower projects and fish migration. It also demonstrates the importance of mapping of barriers in river systems to ensure that this information is available to key lead agencies such as NEMA, ERA and DWRM when reviewing projects prior to approval.



Figure 5-15: Section of the semi-natural upstream fish passage constructed at the Kikagati Hydropower Project, Isingiro District, Kagera River on the boundary with Tanzania (photo by GET FiT Uganda).





Figure 5-16: Upstream fish passage at Nyamagasani 2 HPP, Kasese District. Left photo: Inside the passage with vertical slots between stepped pools. Photo above: Outside of passage with concrete slab to protect against flooding filling passage with materials (gravel, sand) and sections with openings to ensure light inside (photos by GET FiT Uganda).

In terms of alien invasive species, there are requirements in the National Environment Act, 2019, Section 114, to assess risks of introducing invasive species and to undertake measures to avoid such introductions. In terms of the water hyacinth, this aquatic, invasive plant species is to be collected and disposed of at hydropower projects rather than to be flushed downstream.

Finally, lead agencies undertake follow-up including site inspections. Agencies like ERA and DWRM require licensees to monitor and report on measures being undertaken to address their environmental obligations on a quarterly basis. This is a key response to follow up on biodiversity. Projects are also obliged to undertake Environmental Audits annually and/or periodically by registered experts and submit these to NEMA, to evaluate whether environmental requirements defined at the time of project approval are fulfilled.

5.6 Recommendations

Important impacts on biodiversity mainly originate from generation projects, particularly hydropower, and from transmission lines. The recommendations listed below are therefore mainly concerned with these types of Electricity Supply Industry projects. In terms of hydropower, some of the recommendations from Section 4 above on water resources are included below as well due to the importance for biodiversity.

5.6.1 Policy

1) Environmental Flow: DWRM, in collaboration with ERA and NEMA, should develop more specific requirements and supporting guidance for environmental flow releases at hydropower projects, including for hydro-peaking operations. The requirements and guidance should cover environmental flow assessments, release arrangements, monitoring, and documentation. Inter-agency collaboration is needed for practical and coordinated requirements.[4]
2) Fish Passage: NEMA, in collaboration with ERA, should develop more specific requirements and supporting guidance for upstream and downstream fish passage at hydropower facilities, which will also be useful for non-hydropower dams and weirs.
3) Hydropower Pollution: DWRM, in collaboration with ERA and NEMA, should develop more specific requirements and supporting guidance for specific hydropower facilities at risk of causing pollution, including sediment flushing from dams, releases from powerhouses, releases from switchyards, and the designs of oil/water separators.[3]

5.6.2 Implementation and Actions

1) Environmental Flow: DWRM, in collaboration with ERA and NEMA, should review existing environmental flow release conditions in permits and existing arrangements at projects to clarify conditions and improve arrangements where necessary.[5]

[4] Same as in Section 4.6.1.
[5] Same action as listed in Section 4.6.2.

2) Fish Migration: NEMA, in collaboration with ERA and fisheries authorities, should undertake studies of rivers likely subject to future or further hydropower development (e.g., Achwa, Aswa, Kibale, Lamia, and lower Rwimi rivers) to understand the potential presence of existing barriers (natural or man-made) to upstream fish migration as well as the presence of migratory fish species. This will inform decision-making and defining potential requirements to install upstream fish passage and require measures for safe downstream fish passage (e.g., use of "fish-friendly" turbines or construction of bypass structures to reduce fish mortality and injury through turbines or over spillways).

3) Cumulative Impacts: MEMD, in collaboration with MWE, NEMA, UWA, DWRM and ERA, should undertake a more holistic analysis of the White Nile system (from Lake Victoria to the border with South Sudan) based on assessment of cumulative impacts to provide a basis for a balanced development of hydropower resources along what is the backbone for electricity generation in Uganda and the most affected river system.

4) Hydropower Pollution: NEMA, in collaboration with ERA and DWRM, should review existing hydropower facilities at risk of causing pollution, including sediment flushing, powerhouses, switchyards, and oil/water separators, and clarify requirements and improve arrangements where necessary.[5]

5) Co-generation Projects: NEMA, in collaboration with ERA and DWRM, should review existing effluent releases and effluent treatment plants at sugar factories/co-generation projects, and clarify requirements and improve arrangements where necessary. [6]

6) Water Conflicts: DWRM, in collaboration with ERA, DWRM and other stakeholders, should avoid and minimise conflicts over water resources by proper mapping and engagement of projects and water users along a river, undertake appropriate hydrological assessments prior to project design, consider future water needs,

[6] Same action as listed in Section 4.6.2.

and monitor water quantity and quality to inform future water resources management.[6]

7) Biodiversity Action Plan: Project developers should, where important or high-value biodiversity is impacted, ensure that the Environmental and Social Management Plan for the Electricity Supply Industry project in question include a specific Biodiversity Action Plan with concrete conservation actions and monitoring that can document measurable outcomes for biodiversity.

8) Cumulative Impacts: MWE, in collaboration with MEMD, NEMA, ERA, UWA, and NFA, should assess cumulative impacts on protected areas, natural forests, and important habitats that require a more holistic approach to impact identification, assessment and mitigation as opposed to a project-by-project perspective that bit-by-bit has resulted in the loss and fragmentation of important habitats.

9) Collaboration: ERA should strengthen inter-agency collaboration with NEMA, UWA and DWRM, including joint inspections, to ensure that electricity generation projects avoid and minimise adverse impacts on biodiversity.

5.7 References

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SOCIAL ENVIRONMENT



Penstock of one of the hydropower projects traversing populated areas in Kasese District (photo by GET FiT Uganda)

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SOCIAL ENVIRONMENT



Penstock of one of the hydropower projects traversing populated areas in Kasese District (photo by GET FiT Uganda)

6 SOCIAL ENVIRONMENT

6.1 Introduction

6.1.1 Background

Substantial growth in electrification and provision of modern energy services is required for social and economic development, including achieving national development objectives set in the Uganda Vision 2040 and the UN Sustainable Development Goals 7 on ensuring access to affordable, reliable, sustainable, and modern energy for all.

While Uganda's energy mix has been and continues to be dominated by biomass sources (fuelwood and charcoal), the national rate of electricity connectivity access has substantially increased from 5% as of 2002 to 57% in 2022, with 19% on-grid and 38% off-grid access (MEMD, 2023). The rate of grid electricity access is targeted to be 80% by 2040 (MEMD, 2023).

Many people, businesses and industries benefit greatly from the generation, transmission, and distribution of electricity. However, there is typically a much smaller number of people experiencing adverse impacts due to loss of land, loss of assets, or loss of access to natural resources such as water or forest products. Many of the people exposed to these adverse impacts often do not necessarily benefit from access to electricity.

6.1.2 National and International Legal Frameworks

The following legislation are among the most relevant to the management of the social environment in the different electricity project settings in Uganda:

1) Constitution of the Republic of Uganda, 1995 as amended.
2) National Environment Act, 2019.
3) Electricity Act, 1999 as amended.
4) Land Act CAP 227 as amended.
5) Land Acquisition Act CAP 226.

6) Water Act CAP 152 (currently under review).
7) Museums and Monuments Act, 2023.
8) Children Act Chapter 59.
9) Employment Act, 2006.
10) Public Health Act CAP 281.
11) Occupational Safety and Health Act, 2006.

Multiple regulations under the above-listed acts are also relevant for the social environment, including the National Environment (Environmental and Social Assessment) Regulations, 2020.

Uganda has also signed and ratified several international agreements relevant to the social environment, including:

1) UN Convention on Protection of World Cultural and Natural Heritage (World Heritage Convention), 1972.
2) UN Convention for the Safeguarding of the Intangible Cultural Heritage, 2003
3) Several conventions under the International Labour Organisation (ILO).

Instruments have been developed under these agreements and Uganda has undertaken measures to implement these in the national context.

6.2 Driver and Pressures

The main underlying driver of change is the societal need for electricity (see Section 3.1.1) that results in construction and operation of generation projects and the associated transmission and distribution networks to connect to end users of electricity.

Generation, transmission and distribution projects may result in different pressures on the social environment, including:

1) Land acquisition for projects, to provide for access roads and other associated project infrastructure.
2) Changes in land use associated with projects, such as conversion of a particular land use to sugar cane for sugar factories (and thereby also co-generation plants), land use restrictions introduced by projects such as reservoir buffer zones and wayleaves, as well as indirect impacts due to influx of people or new economic activities.
3) Projects often disrupt social relationships and social networks within communities.
4) Water abstraction, particularly for the non-consumptive water use for hydropower generation.
5) Changes in the timing of river flows due to hydropower reservoirs or hydro-peaking.
6) Effluents and sediment flushing resulting in water quality changes (pollution) during construction activities or operation of generation projects, and waste disposal into water bodies.

There are also "positive pressures" such as:

1) The need for jobs and social services for improved standards of living.
2) The need to enhance energy security and increase access to modern clean energy.
3) The need for change to clean energy with the replacement of biomass for institutions or households' energy needs with electricity.

These pressures can lead to changes in the state of the social environment that subsequently cause impacts that need to be managed. These cause-effect chains are illustrated in Figure 6-1 below through the DPSIR model, which summarises the main driver, the resulting pressures, the main changes in the state of the social environment that may result from the pressures, the subsequent impacts, and responses. These elements are discussed further in Sections 6.3, 6.4 and 6.5, respectively. Recommendations are summarised in Section 6.6.

Health and safety issues for local communities affected by Electricity Supply Industry projects are discussed in Section 7.

6.3 States of the Social Environment

6.3.1 Land Taken or Affected by Existing Infrastructure

Current electricity infrastructure affects land use directly through land take where infrastructure or associated facilities are located as well as any buffer zones or wayleaves where restrictions on land use may be necessary.

Generation projects typically require a relatively well-defined area. The cumulative land taken by generation projects has increased over time with the growing number of generation projects as illustrated for instance in Figure 2-7, page 42 above, that show the near threefold increase in generation capacity from 2009 to 2023.

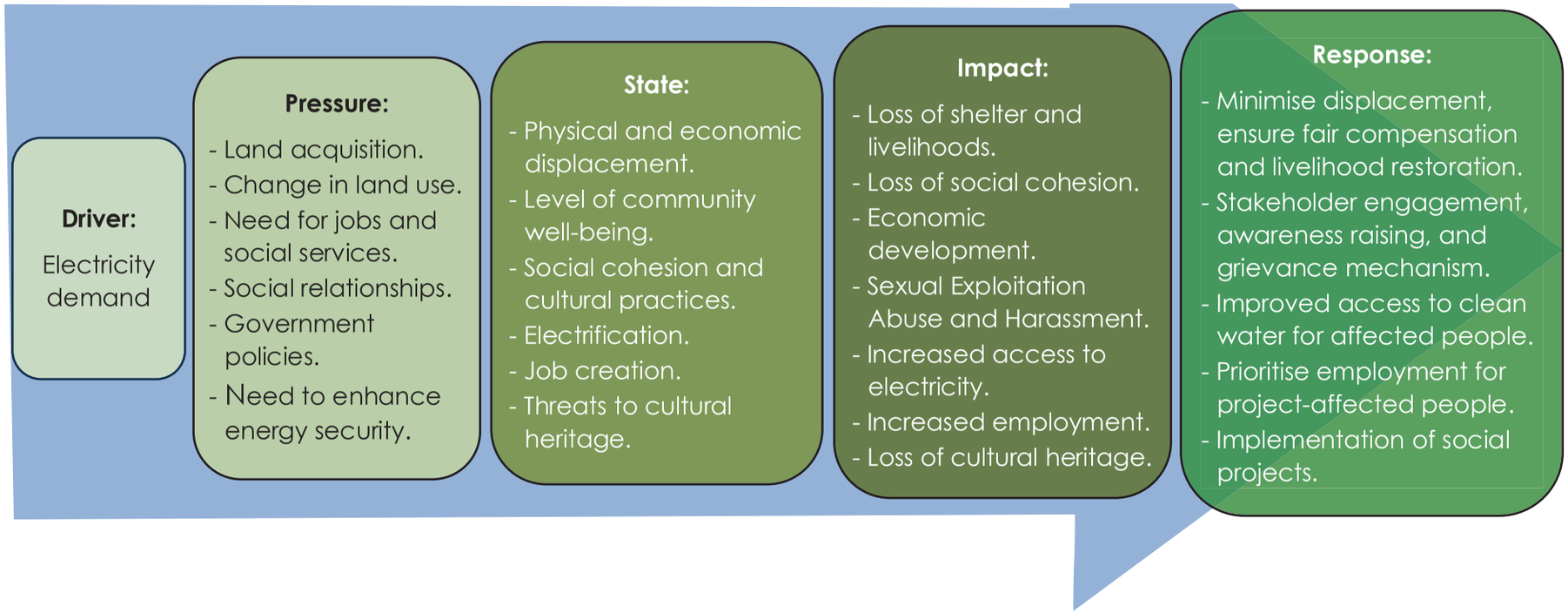


Figure 6-1: Key elements in the DPSIR model summarising the main pressures, states, impacts and responses concerning the Electricity Supply Industry's effects on the social environment.

The extent of land taken varies widely from project to project, and there is also considerable variation between projects of similar electricity generation capacity. Figure 6-2 below shows the land taken at project completion (measured in hectares) per GWh of electricity produced in an average year across 14 completed small hydropower projects.[7]

It should be noted that the exact extent to which these data are representative for the generation segment in Uganda, generally will not be known until a more complete review has been undertaken. Nevertheless, the comparison between these 14 projects shows that the number of hectares taken per GWh produced varies almost 17 times between the projects (see Figure 6-2).

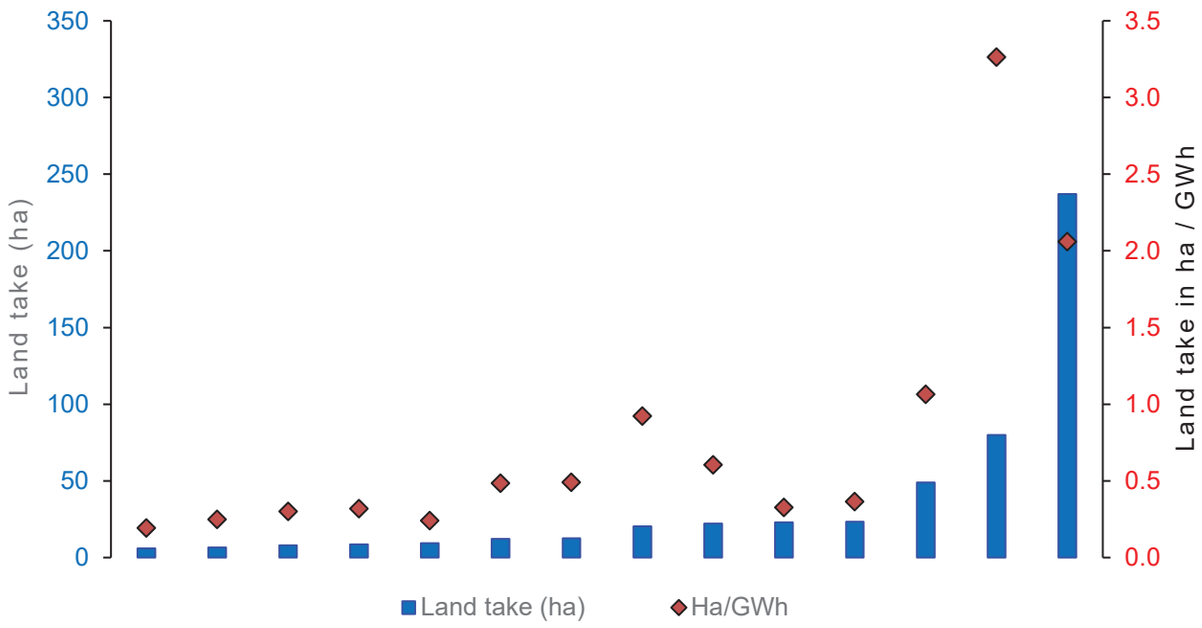


Figure 6-2: Total land taken (ha, blue bars) and land taken per GWh produced in an average year (ha/GWh, red squares) for 14 small hydropower projects (source: GET FiT Uganda).

Using the same 14 projects as the data source, the land acquisition planned at the time of project approval often increased substantially by the time of project completion. For eleven (11) out of 14 projects, the

[7] The 14 smaller hydropower projects referred to in this section are Kikagati, Kyambura, Lubilia, Muvumbe, Ndugutu, Nkusi, Nyamagasani 1, Nyamagasani 2, Nyamwamba, Rwimi, Sindila, Siti 1, Siti 2, and Waki.

land acquisition proved to be substantially higher than planned and land take increased up to more than four (4) times by the time of project completion (see Figure 6-3). This indicates that the information used during decision-making and project approval was not adequate.

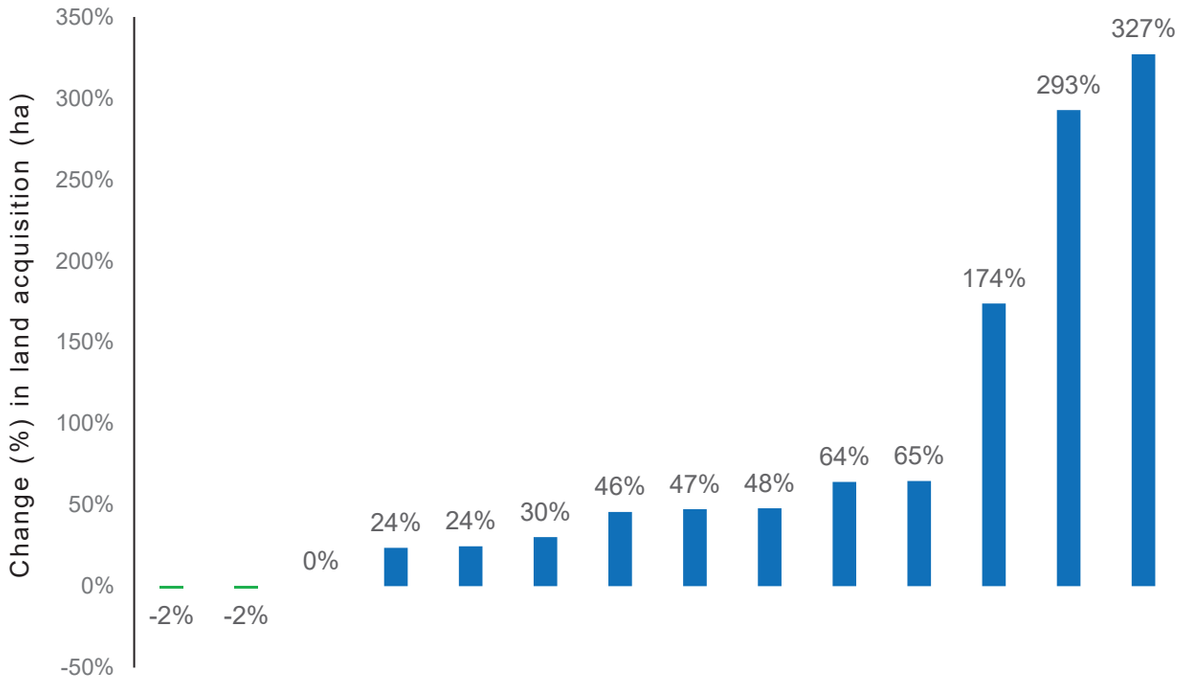


Figure 6-3: Relative change (%) in land acquisition (ha) from the time of project approval to project completion for 14 small hydropower projects (source: GET FiT Uganda).

Comparisons were also undertaken for the 14 hydropower projects in terms of physical displacement (resettlement) and economic displacement (loss of land, loss of access to natural resources, etc.). The comparisons showed similar trends of unrealistic impact assessments at the time of feasibility studies and project approval. Most projects resulted into many more significant impacts than those that had been projected. The extent of economic displacement varies widely from project to project, and when comparing projects of similar size and electricity generation.

Figure 6-4 below shows the number of households economically displaced by the time of project completion. A comparison between these 14 projects shows that the number of households economically displaced per GWh produced in an average year vary from almost none (near zero) to more than eight (8) households per GWh (see Figure 6-4).

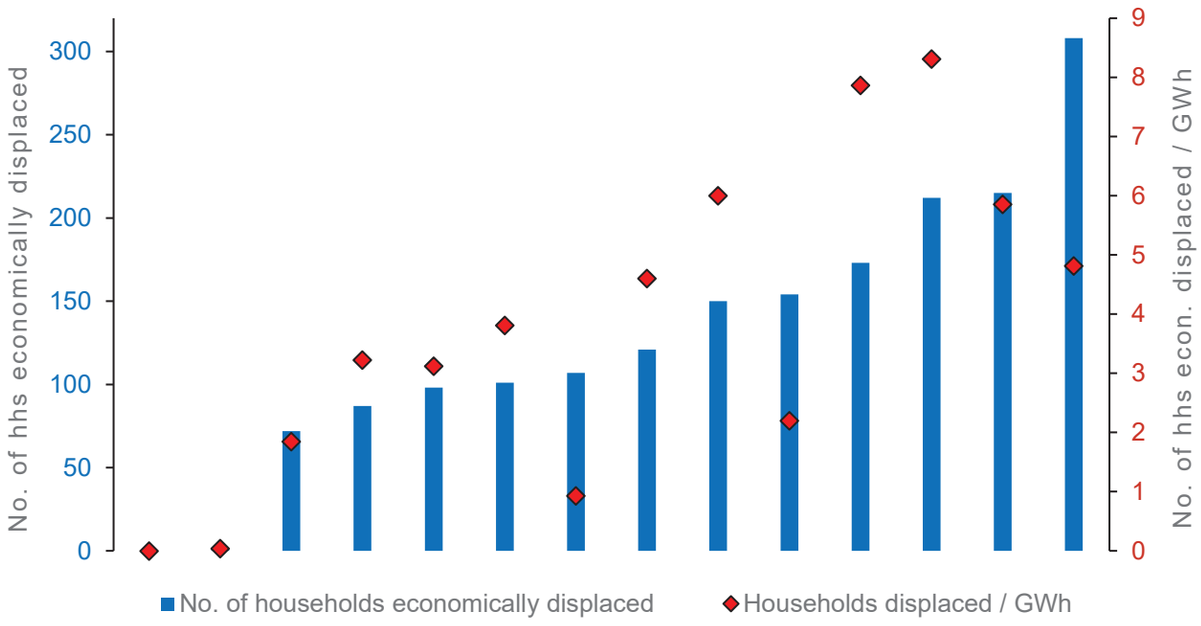


Figure 6-4: Total number of households (hhs) economically displaced (blue bars) and no. of households economically displaced per GWh produced in an average year (no. of hhs/GWh, red squares) for 14 small hydropower projects (source: GET FiT Uganda).

Looking at the number of households expected to be economically displaced at the time of project approval and comparing it with the actual numbers of displaced households at project completion, shows that nine (9) out of 14 projects experienced an increase in economic displacement (see Figure 6-5). This unplanned increase in economic displacement from the time of project approval to completion increased more than 4 times.

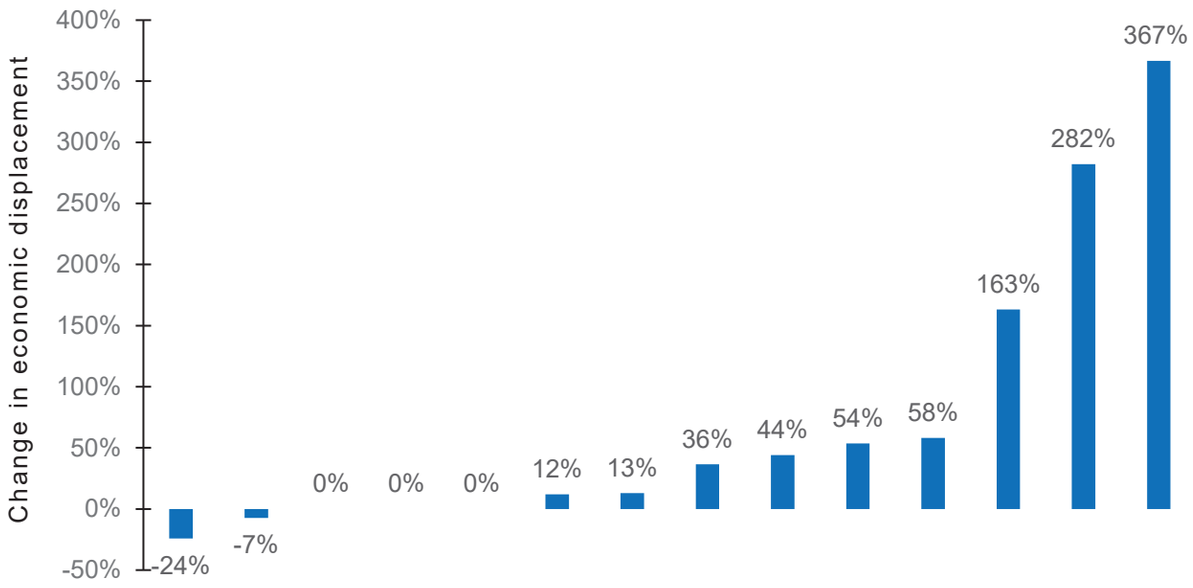


Figure 6-5: Relative change (%) in number of households (hhs) economically displaced from the time of project approval to project completion for 14 small hydropower projects (source: GET FiT Uganda).



Figure 6-6: Damage and additional land take during construction of access road to a small hydropower project (photo by GET FiT Uganda).



Figure 6-7: Damage beyond the acquired land during construction of headrace canal at a small hydropower project (photo by GET FiT Uganda).

The extent of physical displacement also varies widely from project to project, but because the total number of households resettled is substantially smaller than the number of households having their land or livelihoods affected, the variation between projects is also smaller. Figure 6-6 below shows the number of households physically displaced at the time of project completion. A comparison between these 14 projects shows that the number of households physically displaced per GWh produced in an average year vary from none (near zero) to almost 1.4 households per GWh (see Figure 6-8).

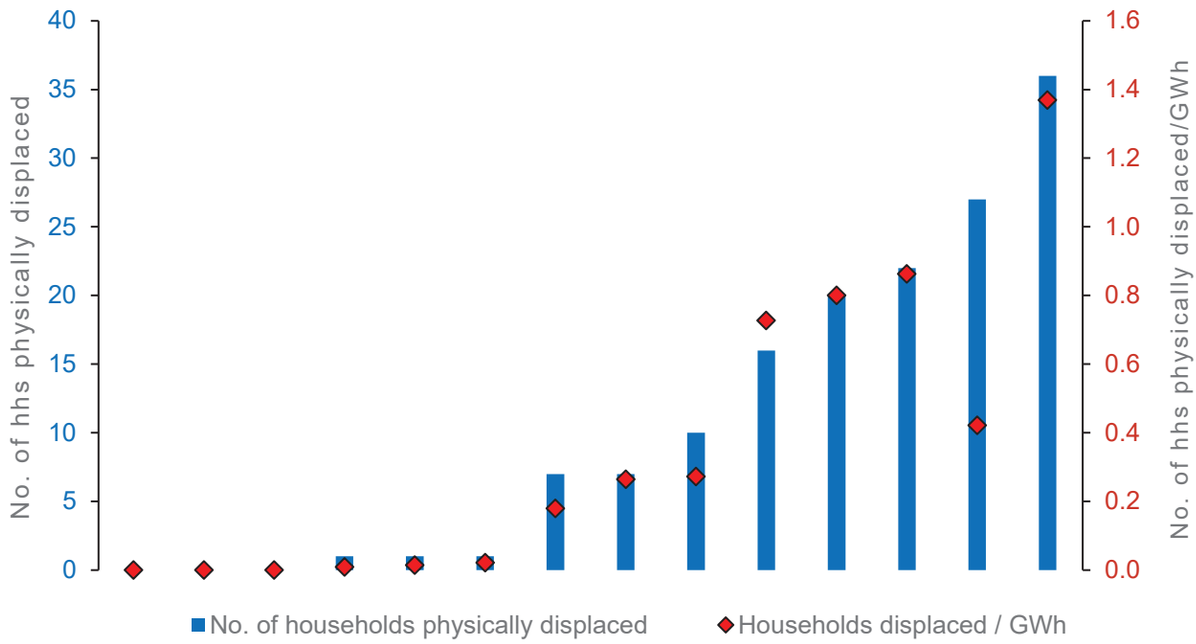


Figure 6-8: Total number of households (hhs) physically displaced (blue bars) and no. of households physically displaced per GWh produced in an average year (no. of hhs/GWh, red squares) for 14 small hydropower projects (source: GET FiT Uganda).

Looking at the change in number of households expected to be physically displaced at the time of project approval and comparing it with the actual numbers at project completion shows a different picture than in the case of land take and economic displacement above.

Possibly, the costs associated with resettlement for internationally funded projects that needed to meet international standards (which was the case for all 14 projects) provided a strong incentive for the project developers to avoid and minimise physical displacement. For instance, projects were required to ensure new houses for resettled households and due to the low quality of houses abandoned the replacement houses represented a major improvement for most households (see Figure 6-9).



Figure 6-9: Example of replacement house provided to a physically displaced household at the Nyamagasani 2 HPP (photo by GET FiT Uganda).

Seven (7) out of 14 projects slightly reduced the number of households resettled from what was expected at project approval to what had been undertaken at project completion (see Figure 6-10). Three projects experienced an increase while for the remaining four (4) projects there was no change. The stark difference between the escalating economic displacement and the smaller changes for physical displacement for the 14 GET FiT-supported projects indicates that dedicated efforts by project developers are able to mitigate unfortunate escalation in displacement.

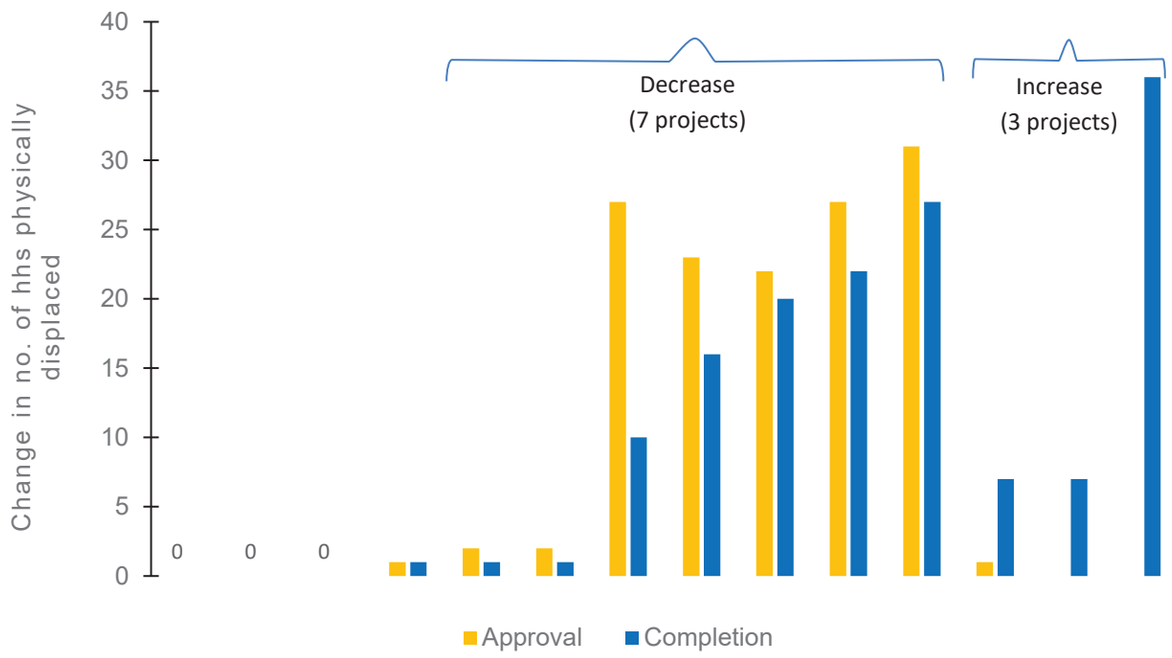


Figure 6-10: Change in number of households (hhs) physically displaced from the time of project approval (orange bars) to project completion (blue bars) for 14 small hydropower projects (source: GET FiT Uganda).

Large areas have been converted to sugar cane primarily for sugar production but with biomass (bagasse) co-generation projects being part of the sugar factory complexes. The electricity generation that relies on a bagasse supply chain can also be seen as having contributed to conversion of land cover to sugar cane and loss of land from natural vegetation cover or agricultural land to plantations of sugar cane.

A systematic analysis for land take and displacement has not been undertaken for transmission projects. Due to the long distances of transmission lines required to transfer electricity from the generation sites to the end users (see Section 2.9 above), substantial land acquisition and displacement are inevitable for the transmission segment of the Electricity Supply Industry. Table 6-1 shows the recommended wayleave distances for different voltages of transmission lines, and these are illustrated in Figure 6-11.

Table 6-1: Recommended wayleave distances for transmission lines of different voltage levels.

Voltage	Right of way	Easement	Wayleave corridor (both sides of centre line combined)
66 kV	2.5 m + 2.5 m	5 m + 5 m	15 m
132 kV	2.5 m + 2.5 m	12.5 m + 12.5 m	30 m
220 kV	2.5 m + 2.5 m	17.5 m + 17.5 m	40 m
400 kV	5 m + 5 m	25 m + 25 m	60 m

Source: UETCL, undated.

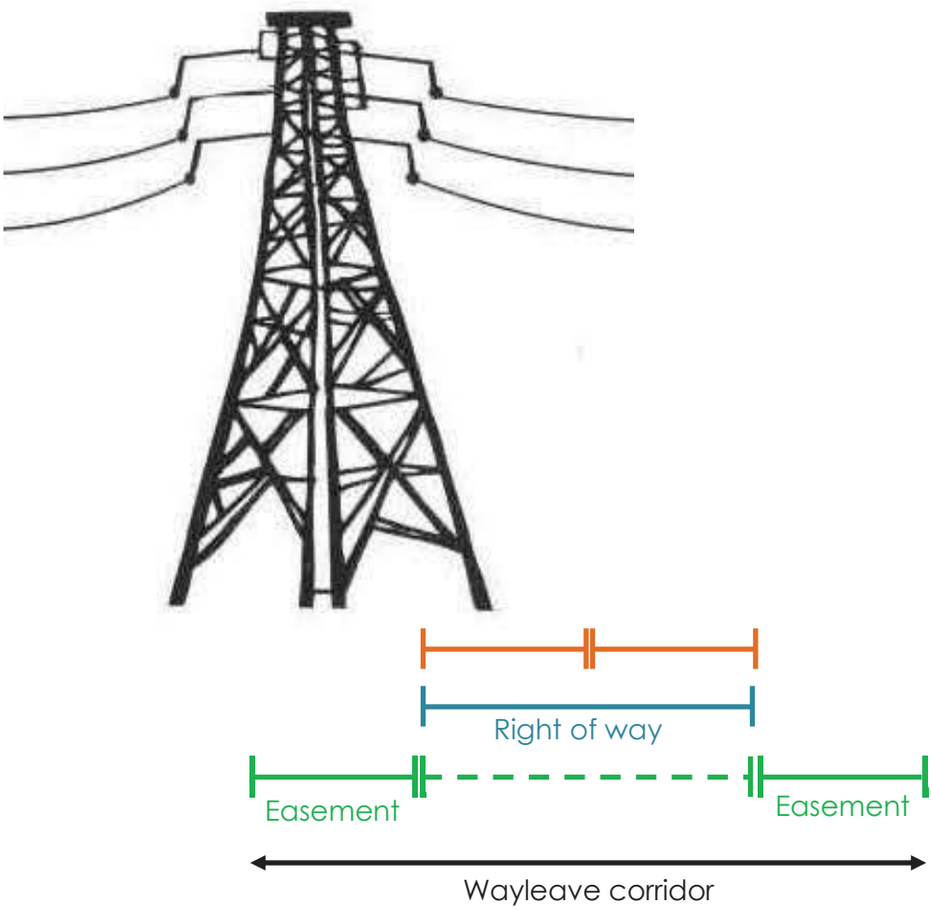


Figure 6-11: Illustration of wayleave corridor for transmission lines (modified from UETCL, undated).

Even if distribution lines (medium and low voltage lines) are not substantially covered in this report (see Section 1.3.6 above) it is worth mentioning that land is typically not acquired for the distribution lines, but written consent is sought from the landowners. On the other hand, land for substations associated with the distribution network is acquired, crops destroyed during the installation of the poles and distribution network are compensated. For 33 kV distribution lines, a corridor of 5 m (2.5 m + 2.5 m) is typically required and certain restrictions on land use are associated with installing medium voltage lines on any land. The restrictions include not constructing houses or growing trees in this corridor.

6.3.2 Land Take from Proposed Infrastructure

Expanding electricity access and ensuring people have reliable access to electricity require substantial expansion not only of generation installations but also transmission and distribution networks. As can be seen for instance in Figure 2-30, page 70, substantial expansion of the transmission line network is planned, and based on the wayleaves indicated in Table 6-1 above considerable land acquisition and displacement will take place in the future. The specific projects and their respective planning processes will have to carefully identify and assess the implications both from the individual projects and the cumulative changes where applicable.

6.3.3 Direct Employment

The construction and operation of generation, transmission and distribution projects generate many jobs both during the short-term construction phase and the long-term operation and maintenance phase. Figure 6-12 below shows the total number of staff as well as the breakdown of the total number into generation (multiple generation projects), for transmission (UETCL), for distribution (UEDCL and multiple concessionaires), and off-grid (WENRECO and KIS).

In 2023, the reported number was approximately 5,000 workers. The figures are based on data reported to ERA by licensees for the operation phase. It should be noted that not all generation projects are included in the numbers, and these numbers therefore substantially underestimate the staff involved in operation of generation projects. Figure 6-13 shows

the reported number of staff by type of generation project and small hydropower is the group of projects with most staff.

Generally, the Electricity Supply Industry projects generate many more jobs during construction compared with the operation and maintenance phase, as illustrated by the more than 13,000 jobs created from 2014-2022 during development of 17 small renewable energy projects (GET FiT Uganda, 2023). The jobs during project operation tend to be more technical and require qualifications that may not be easily met by local people. Further, very many indirect jobs associated with the Electricity Supply Industry are not included due to limited availability of data.

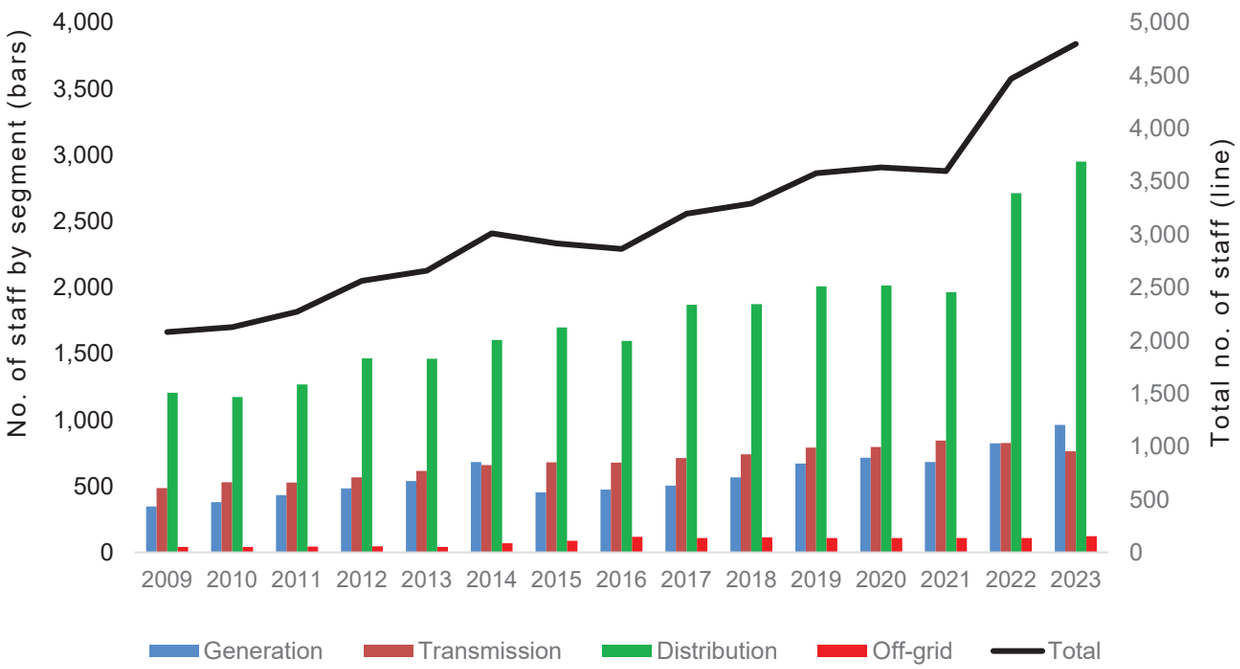


Figure 6-12: Number of staff reported for licensees involved in generation, transmission, distribution and off-grid projects (bars, left axis) and the total for all segments (line, right axis) from 2009 to 2023 (source: ERA Database, 2023).

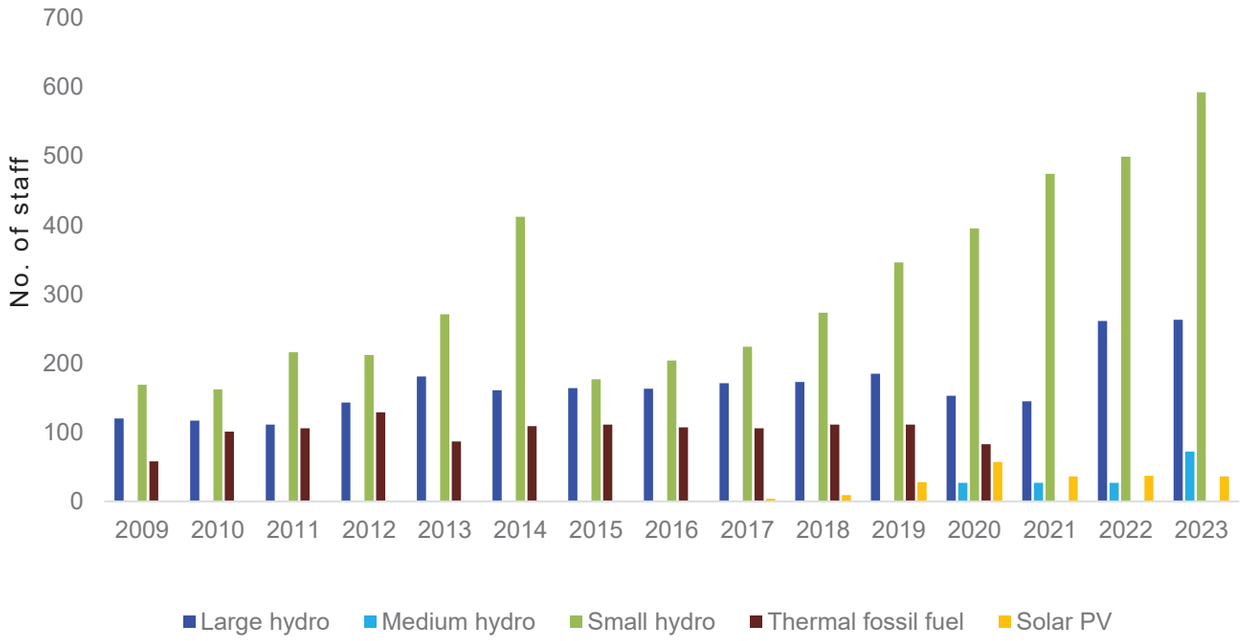


Figure 6-13: Number of staff reported for licensees involved in different types of generation projects from 2009 to 2023 (source: ERA Database, 2023).

6.3.4 Other Changes in the Social Environment

Electricity Supply Industry projects may change local people's access to resources such as water, forests, fish, arable land, etc. through limiting or blocking opportunities for access (e.g., inundation due to dam construction) or introduce restrictions on the use of areas (e.g., safety zones).

The level of societal and community social cohesion as well as the local or traditional ways of life may change, particularly due to large Electricity Supply Industry projects that result in substantial influx of project workers or associated economic opportunity seekers. It is important that project developers invest in obtaining a robust understanding of cultural integrity and appreciate local traditions, customs, and heritage, which are integral to the identity of the community. If a project is in an area with Indigenous Peoples, such groups may be particularly vulnerable to changes.

The levels of sexual exploitation, abuse and harassment may increase following a typically male-dominated workforce that can use project positions of power or increased wealth from project salary to take advantage of less privileged groups within the local communities.

Changes in water resources, either quantity or quality, can substantially alter people's livelihoods. Water abstraction for hydropower will reduce access to water along the diverted river section. Effluents from Electricity Supply Industry projects and sediment flushing from hydropower projects result in water quality changes (pollution) during construction activities or operation of electricity projects.

Many of the Electricity Supply Industry projects provide support to communities in the form of social projects, for instance Corporate Social Responsibility (CSR) initiatives. Such initiatives typically create positive change both for people affected directly by the projects and for other members of the wider community. Typical initiatives include improvements in, or support to, community water supply schemes, local education facilities, local healthcare facilities, or other local facilities or services, as well as support for various income generation activities.

Communities may also experience changes in access or transportation through project-financed upgrading of access roads, construction of new access roads, or improved or new bridges (see Figure 6-14). Electricity Supply Industry projects need goods and services, which may increase the demand at local level and increase opportunities for those providing the required goods or services.



Figure 6-14: Example of local infrastructure constructed with support from small hydropower projects: Community bridge across river (upper photo, by ERA) and renovated primary school (lower photo, by Serengeti Energy Ltd.).

Where electricity projects increase access (connections) to electricity, there are clear, positive changes for people connecting. The distribution projects are typically the projects that people experience as relevant to increase access to electricity. The transmission and generation projects are, however, also essential for the supply of electricity even if experienced as projects of less direct positive change in terms of electricity access by local people who in some instances may be

adversely affected by a generation or transmission project but not benefitting from electricity supply themselves.

Where electricity reduces reliance on biomass energy, the communities where biomass is harvested may experience improved access to natural resources because less forest is cut to provide biomass energy.

No specific gender analysis was undertaken for this ESISOER. However, gender is a relevant aspect in the Electricity Supply Industry and in the context of environmental issues. Environmental impacts as well as climate change may disproportionately affect women and girls, particularly the poorest ones. For instance, reduced access to water due to a river diversion for hydropower may affect women and girls responsible for collecting water more than men and boys. There are often unequal opportunities to obtain land rights or to influence decisions on land, including whether compensation for land and crops following displacement should be in-kind or cash, the latter which may not be availed to women as the man is often recognised at having rights over land and receiving compensation.

ERA is active in the Women in Energy Sector Project, spear-headed by the eminent Women in the Energy Sector that aims to inspire young females to engage in science, technology, engineering, and mathematics. Many schools in different parts of the country have been visited.

6.4 Impacts

Social impacts associated with electricity projects activities will emanate from the construction and operation phases. Adverse impacts may be loss of livelihoods resulting from physical and economic displacement, including loss of access to natural resources or income opportunities. Loss of social cohesion, social networks, and unwelcome changes to local culture and traditions, including impacts on cultural heritage, are also typical impacts.

On the positive side, there will be employment and increased local procurement of goods and services that result in economic benefits locally. Improved social service delivery can improve health and well-being and improve the quality of education. Projects also result in improved access to electricity and more reliable electricity supply, even if these impacts may not be felt locally for generation and transmission projects.

It is important to note that the magnitude and scale of the social impacts, both negative and positive, vary with the scale of the project. The strategies to identify relevant impacts and manage them appropriately will also affect the level of impacts experiences in affected communities.

6.4.1 Loss of Livelihoods

Physical and economic displacement, land fragmentation from project infrastructure, and loss of access to resources due to restrictions on land use or natural resources use (e.g., forests, water, fish) can result in loss of livelihoods and worsened living conditions if these impacts are not adequately managed. The development of electricity infrastructure, especially the generation and transmission facilities, may physically displace people, or lead to the loss of assets and substantial disruption of livelihoods.

While in some cases, the impact may be relatively small or even negligible, other projects such as hydropower and transmission projects may result in substantial physical displacement. Small, run-of-river hydropower projects may, if they are clustered within a single river basin or region, cause displacement impacts comparable to those from individual larger projects (EIB, 2019). Several of the small hydropower projects in Uganda are in high rainfall areas with productive rainfed agriculture supporting a high population density that result in substantial displacement. Such contexts require very careful planning and management to minimise displacement impacts and loss of livelihoods.

Electricity generation facilities are often located far from electricity demand centres. Power transmission lines are therefore required to transmit the electricity generated to the end consumers. Amortisation

and maintenance costs of the long, expensive high-voltage transmission lines are reflected in energy costs. Resettlement is typically required for transmission lines. Forests and crops are damaged during the installation of transmission lines, and tall trees will not be accepted in the wayleave corridor. Livelihoods reliant on the wayleave corridor will be listed and in need of compensation in-kind or cash.

Additionally, there are fears that electromagnetic fields created around high-voltage lines represent health risks. This does not appear to be support by robust science, but the fear may nevertheless represent a perceived loss of livelihood or well-being that needs to be considered.

6.4.2 Social and Cultural Impacts

Many of the Electricity Supply Industry projects are in rural areas where a substantial investment project with a considerable workforce during construction can impact social and cultural conditions. Community dynamics may change and social cohesion be lost due to influx of workers and opportunity seekers with different cultural norms and practices, and tensions may arise as economic benefits or opportunities are typically not shared equitably.

Cultural heritage, both tangible and intangible, may be impacted particularly where there is considerable land required or culturally important sites are disturbed directly (e.g., inundation by a reservoir, removal due to excavations) or indirectly (e.g., reduced flow over an important waterfall due to river diversion).

Indigenous Peoples often have unique cultures and social structures that may be more impacted than other local communities due to the marginalised status of most Indigenous Peoples.

6.4.3 Social Services

Social services may be both positively and negatively impacted, depending on the extent to which project support is provided to social services as part of managing risks and impacts.

An influx of workers and opportunity seekers into a project community will typical strain existing, and often insufficient, infrastructure and services. This can lead to increased challenges in providing adequate housing, healthcare, water supply and sanitation, and other essential amenities that affects people's well-being. Social services may be overwhelmed. Sexual exploitation, abuse and harassment can increase, and there are often increased risks of communicable disease such as sexually transmitted diseases (e.g., HIV/AIDS). Such adverse impacts require timely and careful management.

There are also examples where electricity projects provide much needed support to education institutions (e.g., new school, additional classrooms, teachers' accommodation, school furniture and materials), support to health care facilities (e.g., new or improved buildings, medicines, equipment), and new or improved water supply systems with new water sources, supply pipes, water tanks, and taps. Project support to social services can be part of mitigation strategies concerning project-affected persons or may go beyond mitigation and cover the wider community members through Corporate Social Responsibility initiatives. Such interventions can ensure substantial positive impacts on the well-being of beneficiary communities.

6.4.4 Improved Income

Employment, whether direct or indirect, ensures improved income and often an element of capacity enhancement and improved skill sets that also facilities individuals' ability to secure future jobs. Direct project employment is typically substantially greater during construction and a larger proportion of the jobs during construction tends to be available to local people while during operations the projects typically require fewer and more specialised skillsets. Dedicated capacity building or training by project developers can enhance the local benefits through a greater share of local people employed during the project and enhanced skillsets beneficial beyond the project.

Increased economic activities, particularly during the construction phase, represent opportunities for economic benefits and income through provision of goods and services to workers or to the companies constructing or operating the project. There may be economic multiplier

effects in the local communities as the increased incomes are spent on other local good or services. Project developers that deliberately seek to source goods and services locally can increase the positive impacts.

Projects can in certain circumstances improve the potential for tourism. A generation project can be an attraction, access roads improving access to an area may open opportunities for tourism, and supply of power may enable investments in new tourism activities. At the same time, careful planning of electricity projects is required to avoid negative impacts particularly on nature-based tourism where certain types of infrastructure may adversely affect the visual appearance of natural areas or reduce presence of wildlife.

6.4.5 Electricity

Projects also result in improved access to electricity and more reliable electricity supply, which is fundamental to many economic activities, important social services, and individuals' well-being. The extent to which this positive impact is experienced locally varies substantially for generation and transmission projects, where local people may not always be connected to electricity. One example of local electrification is the Kabalega Small Hydropower Project which electrified 7 villages in a radius of 1 km from the evacuation line of the project.

6.4.6 Access Roads

Electricity projects often require the development of associated infrastructure such as access roads. Improved access can be a positive impact locally. In certain situations, the opening of access to new areas can also leave areas and resources more readily available for people from outside the local community who may exploit the resources in a manner that adversely affects the local people. Great care therefore should be exercised when opening new access roads.

6.5 Responses

The main response to avoid and minimise negative social impacts is appropriate site selection and identifying project alternatives that

reduce such impacts. Adverse social impacts are undesirable for project developers also because this may result in delays and additional costs, which means there is an incentive to minimise social risks assuming these risks are understood by the developers.

The challenges often come when limited and high-risk, early-stage development funding available for the project developer limits the level of site surveys, alternatives' considerations, and stakeholder engagement. The best options to avoid and minimise social impacts may not be identified due to insufficient studies. At other times, the project alternatives or measures that avoid and minimise social impacts may not be considered technically or economically feasible by the project developer. Finding the balance between these different societal interests is always a key challenge.

ERA has observed that project developers' level of contractor oversight, combined with the skills of contractors, can make a large difference in terms of damage from construction works and escalation of land take. Changes in construction methods required by developers and using highly skilled construction staff have in some projects resulted in dramatic reductions in damage and additional land take, particularly in steep terrain with high risks of material spilling downslope and damaging land and crops (Figures 6-15, 6-16, and 6-17).

Lead agencies like NEMA and ERA request consideration of project alternatives and that land acquisition and compensation are undertaken in line with relevant regulations, including the approval of the Chief Government Valuer. There may be a public hearing before project approval to collect views on the proposed project as part of informing lead agency approval (or rejection), including to inform which conditions should be attached to an approval.

The approvals of lead agencies (e.g., NEMA, ERA, DWRM) contain several conditions and requirements related to various social and cultural issues to ensure impacts are managed. The implementation of a community grievance management mechanism at each project is also intended to identify and resolve any issues, including unexpected impacts that were not anticipated during project planning or approval.



Figure 6-15: Construction of a wide access road using large machinery in steep terrain (upper photo, before change in construction method) compared with the modified, more manual approach (lower photo) at a small hydropower project (photos by GET FiT Uganda).



Figure 6-16: Poor excavator operator performance with excessive spilling of material between access road and river (upper photo) and another excavator operator at the same project avoiding spilling of material almost entirely (lower photo) despite steep terrain (photos by GET FiT Uganda).



Figure 6-17: Excavator operator leaving an elevated berm on the outside of the cut slope to contain material and avoid spilling of stones and soil that would otherwise cause damage to crops downslope (photo by GET FiT Uganda).

6.6 Recommendations

The most substantial social impacts from the Electricity Supply Industry are typically caused by generation and transmission projects due to their greater land requirements. Among the recommendations listed below, there are some repeated from Section 4 Water Resources above due to the importance of water for people.

6.6.1 Policy

The policy recommendations in Section 4.6.1 above concerning environmental flow and water pollution are relevant for the level of social impacts as well.

6.6.2 Implementation and Actions

Several of the recommended implementation and actions in Section 4.6.2 above are relevant also for social impacts, including those on environmental flow, water pollution, ensuring that water users adversely

affected are provided with safe, alternative water supply, as well as avoiding and minimising conflicts over water resources.

In addition, the following is recommended for project developers:

1) Undertake appropriate early-stage studies with priority on avoiding and minimising displacement, particularly physical displacement (resettlement).

2) Undertake meaningful community engagement from early planning and incorporate feedback, needs and priorities in project design and decision making. Ensure that women, youth, and other vulnerable groups are given sufficient opportunity to voice concerns, including separate or dedicated engagement for such groups. Also involve local leadership in appropriate ways to foster active participation, ownership and responsibility locally.

3) Implement community grievance mechanism from early stages of project development.

4) Implement fair compensation with priority on in-kind compensation where people are resettled or lose key components of their livelihood. Displaced persons should not be worse off after displacement, preferably better off.

5) Promote fair treatment, non-discrimination and equal opportunity for project workers with priority on local people.

6) Ensure that projects do not significantly affect cultural heritage and archaeological values in line with the Museums and Monuments Act, 2023.

7) For Indigenous Peoples, implement the principles of free, prior, and informed consent (FPIC).

8) Implement social development projects and strengthen social services.

6.7 References

EIB (2019). *Environmental, Climate and Social Guidelines on Hydropower Development*. European Investment Bank (EIB). Available at: https://www.eib.org/attachments/publications/eib_guidelines_on_hydropower_development_en.pdf

GET FiT Uganda (2023). *Annual Report 2022*. Available at: https://www.getfit-uganda.org/annual-reports/annual-report-2022/

UETCL (undated). *Wayleave measurement for the different high voltage transmission lines*. Uganda Electricity Transmission Company Limited (UETCL), Kampala.

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HEALTH AND SAFETY



Tunnelling works during the construction of a hydropower project in Uganda (photo by ERA).

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HEALTH AND SAFETY



Tunnelling works during the construction of a hydropower project in Uganda (photo by ERA).

7 HEALTH AND SAFETY

7.1 Introduction

7.1.1 Background

Health and safety issues have become increasingly important and an integral part of modern environmental and social management, often referred to as environment, social, health and safety (ESHS) management. Management of health and safety risks are of high priority both in national and international requirements for Electricity Supply Industry projects. This covers both project workers' health and safety as well as the health and safety of surrounding communities. This also means that the health and safety issues vary in nature, and there are different types of serious incidents and fatalities among project workers and community members associated with Electricity Supply Industry projects. Multiple measures are available to prevent and mitigate health and safety risks and impacts, and several of these are discussed below.

There are also positive impacts associated with an energy transition away from biomass for cooking and kerosene for lighting, such as improved indoor air pollution and associated health benefits.

7.1.2 National and International Legal Frameworks

The following legislations are among the most relevant to the management of the social environment in the different electricity project settings in Uganda:

1) Constitution of the Republic of Uganda, 1995, as amended.
2) Occupational Safety and Health Act, 2006.
3) Employment Act, 2006.
4) Labour Disputes (Arbitration and Settlement) Act, 2006.
5) Labour Unions Act, 2006.
6) Workers Compensation Act, CAP 225.
7) Equal Opportunities Commission Act, 2007.

8) Whistleblowers Protection Act, 2010.
9) Children Act, 2016 as amended.
10) Public Health Act, CAP 281.
11) Traffic and Road Safety Act, CAP 361.

Multiple regulations under the above-listed acts are also relevant for the social environment, including the National Environment (Environmental and Social Assessment) Regulations, 2020.

Uganda has also signed and ratified several international agreements relevant to health and safety, including several conventions under the International Labour Organisation (ILO).

7.2 Drivers and Pressures

The main underlying driver is the need for electricity (see Section 3.1.1 above) that results in the construction and operation of generation, transmission and distribution projects and associated infrastructure. Decommissioning is less common but may also be a driver that results in pressures and subsequently impacts.

For health and safety, the main pressures include activities and contexts such as:

- High-risk work operations, for instance, work at height, work in flowing water at hydropower projects, using explosives, tunnelling, and working with electrical installations.
- High-risk project facilities, for instance, open water canals at hydropower plants and power lines and electrical components that can be accessed by workers or local people (authorised or unauthorised access).
- Presence of armed security staff at projects and installations.
- Emergencies, for instance, flooding or dam breaks at hydropower projects, penstock bursts at hydropower projects, explosions or fires.

- Noisy or polluting activities or equipment, for instance, construction machinery, operating generation facilities (turbines and generators), and combustion chambers at thermal power plants.
- Need for change to clean energy such as the replacement of fossil fuel in electricity generation and the switch from biomass to electricity in cooking.

Figure 7-1 below summarises the main driver, the resulting pressures, the main state of environment components that may be affected by the pressures, the resulting impacts, and some main responses. Information on the state of the environment and impacts is summarised in Section 7.3 and responses are presented in Section 7.4. Recommendations are summarised in Section 7.5.

Some of the health problems associated with water supply are covered in Section 4 while issues concerning hazardous materials and waste management are discussed in Section 8.

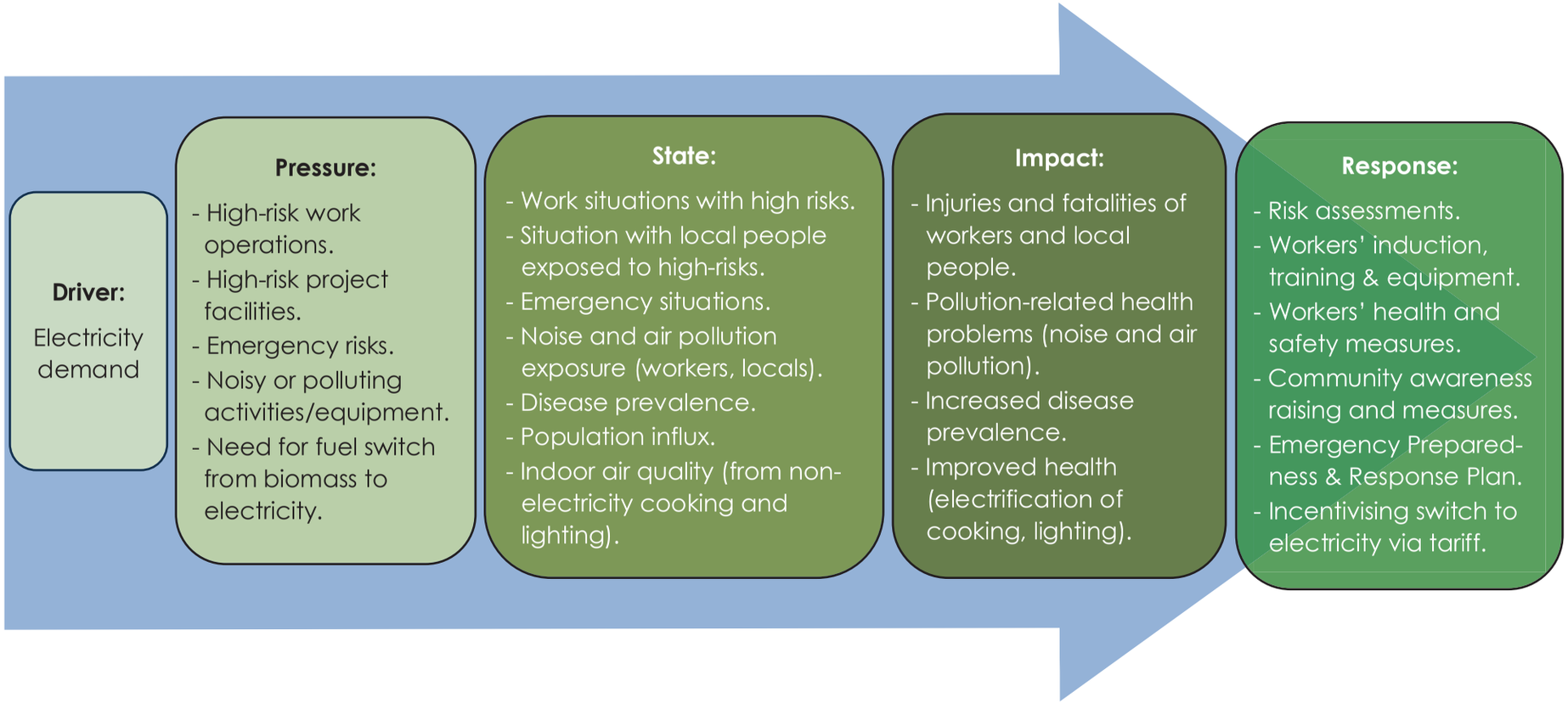


Figure 7-1: Key elements in the DPSIR model summarising the main pressures, states, impacts and responses concerning the Electricity Supply Industry's effects on health and safety.

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7.3 State and Impact

7.3.1 Work Situations with High Risks

Workers' safety may be particularly related to high-risk work situations either during the construction or operation of Electricity Supply Industry projects (see Figure 7-2). For all segments in the sector (generation, transmission, and distribution), the workforce tends to be larger during construction, the number of high-risk work situations is often greater, and the experience and training of workers may be lower than during the project operation phase.

These factors may contribute to a state of higher risks and result in more injuries and even fatalities (impact). Despite the generally lower level of activities, the operation and maintenance phase has resulted in a considerable number of fatalities and serious incidents in the Electricity Supply Industry.



Figure 7-2: High-risk work situation at height during construction of the Nyamaghasani 2 powerhouse (photo by GET FiT Uganda).



Figure 7-3: Spraying of shortcrete on steep rockface to avoid rockfall on workers installing a headrace pipe at the foot of the slope (photo by GET FiT Uganda).



Figure 7-4: Construction works for the Kikagati hydropower dam (photo by GET FiT Uganda).

Examples of incidents with worker injuries and fatalities that happen in the Electricity Supply Industry include:

a. Traffic accidents with light or heavy vehicles at work sites or on the way to work sites.

b. Fall from height during construction works or operation.

c. Health problems due to poor accommodation and living conditions, particularly for construction workers.

d. Slope instability with slope collapse or failure resulting in rocks or other material falling on work areas, particularly in hydropower projects.

e. Rockfall during tunnelling works for hydropower development.

f. Accidents during pipeline inspections (confined space), for instance, in steep penstock pipes at hydropower projects.

g. Drowning during works in a river or waterway for hydropower projects with people being caught by the currents.

h. Electrocution during works on electrical installations such as power lines.

i. Protected areas with wildlife (e.g., national parks, wildlife reserves) represent a particular risk to workers during construction and possibly even more during operation, the latter being when wildlife is more likely to be present in a project area due to lower activity and disturbance levels than during construction (e.g., along transmission line corridors).

Several worker fatalities in recent years have been recorded at Electricity Supply Industry projects and installations in Uganda. These include:

- Fatality at a hydropower construction site following construction truck hitting a construction worker due to failing breaks on a truck.
- Fatality of a driver who lost control over a construction truck on a very steep access road at a hydropower site, and the truck rolled down a very steep slope.
- Fatality of a hydropower operation team member during removal of sediment blockage at drain value with high-pressure water hitting the worker.

- Drowning of a contracted diver trying to clear debris stuck in the sediment flushing (bottom) gate in the dam wall (preventing closing of gate) at an operational hydropower project.
- Drowning of workers of contractors at the intake during underwater inspections during operation.
- Drowning of worker of contractor at the dam trying to dredge and remove logs blocking the flushing gate during reservoir sediment flushing.
- Electrocution during works on electrical installations such as power lines.

These are cases that came to ERA's attention in multiple ways, but these are unlikely to be a complete overview. There are also occasional deaths among workers that happen on construction sites outside work hours and where underlying health issues or other non-work factors may result in death of a worker. This further complicates the scant data available. An example of a data set is the number of accidents reported for the transmission segment from 2014 to 2022 (Figure 7-5). The data are not categorised into fatal and non-fatal accidents, workers and community member accidents, or any other categorisation.

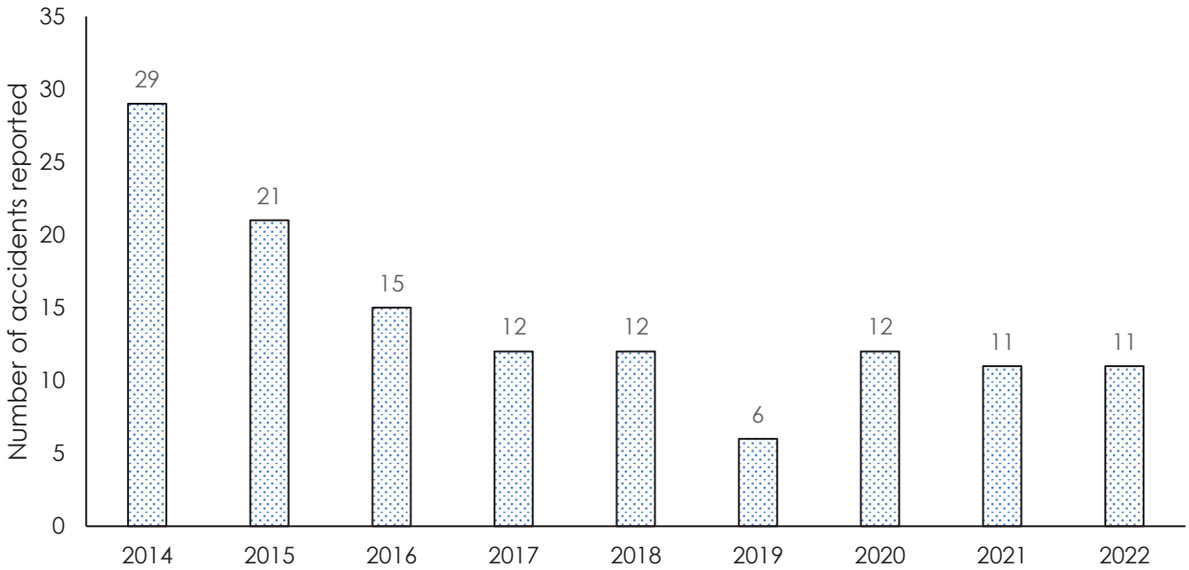


Figure 7-5: Accidents reported from the transmission segment (2014-2022) including community members and staff (source: ERA Database, 2023).

7.3.2 Local People's Exposure to High-Risk Facilities

Electricity Supply Industry projects and infrastructure are in most instances located in community areas where local people may be exposed to facilities that represent risks to their health and safety. This includes normal and authorised access to project areas, for instance, people undertaking daily activities near project infrastructure that represents a risk during certain events (e.g., an emergency due to failure of project infrastructure). This includes unauthorised access to facilities, for instance, trespassing.

Situations representing high risks to local people have been recorded both during the construction and operation of Electricity Supply Industry projects, and high-risk situations can occur for generation, transmission, and distribution projects. High-risk situations include:

a. People drowning in open water (headrace) canals at hydropower projects or canoes coming too close to hydropower dams/intakes/gates and being caught by strong water currents.

b. People being injured by security personnel during trespassing or theft of project materials or equipment.

c. People being electrocuted because of unauthorised access to electrical installations, for instance, attempted theft of materials or illegal connections to energised distribution lines.

d. While rarely reported, there are likely incidents of gender-based violence associated with the Electricity Supply Industry projects.

e. Traffic risks are particularly common where considerable construction traffic passes through populated areas, near schools, and other locations with many people.

Known examples of community member fatalities are listed below. These are cases brought to ERA's attention in different ways but are not a complete overview.

- Drowning of community members in open headrace canals during the operation of hydropower projects.

- Drowning of a community member in a canoe that was carried by river current through a gate spilling water over a hydropower dam during operation.
- Drowning of a pupil who had accessed the headrace canal (with other pupils) for a study tour without authorisation from the project operation team.

In addition to the examples above, there are multiple cases of dead persons carried by rivers ending up at the dam or intake at hydropower projects. The death of these persons is not related to the hydropower projects but large objects in rivers tend to accumulate at dams or weirs.

7.3.3 Emergency Risks

Emergencies may occur during the construction or operation of Electricity Supply Industry projects. Construction phase emergencies may include fire, flooding or major spills of hazardous materials at construction sites. Risks of such emergencies are typically greater at generation projects due to the more complex construction activities, equipment and materials used compared to transmission and distribution projects. Operation phase emergencies may also include fire, flooding, or substantial spills of hazardous materials (e.g., oil).

Hydropower projects with dams and waterways represent certain unique risks, including the risk of:

1. Temporary diversion: Failure of temporary river flow diversion structures (e.g., coffer dams) during construction of hydropower dams or weirs that result in flooding downstream.
2. Permanent dam or weir: Failure of the permanent dam or weir structure resulting either in a gradual or abrupt release of large volumes of water.
3. Permanent waterway: Failure of the waterway (e.g., canal, pipeline, or forebay) resulting in flooding, which may be water under high pressure from a penstock, but typically a lower water volume than for a dam breach.

The above-listed emergencies may be caused by flooding and overtopping of the dam structure or waterway, or by failure of the dam

or waterway structure, failure of the foundation for the structure, or due to landslides affecting the structures.

Temporary diversion

During the short-term construction phase for a hydropower project, there is a need to temporarily divert water away from the section of the riverbed where the dam foundation will be constructed in dry conditions. This is typically undertaken using coffer dams (see Figure 7-6). These temporary dam/flow diversion structures are not constructed for the long-term and can more easily fail or be overtopped during flooding. This can result in a collapse of the coffer dam and flooding of the downstream area where the nearby construction area and workers are particularly at risk.



Figure 7-6: Temporary coffer dam for diversion of water (upper photo) away from the construction area immediately downstream (lower photo) that will be a high-risk location in case the coffer dam fails (photo by GET FiT Uganda).

Permanent dam or weir

Dam safety during the longer-term project operation is an important concern for hydropower dams, particularly for dams with a substantial volume of water behind the dam in the reservoir and where downstream areas are populated or have infrastructure. Most hydropower projects in Uganda do not have large dams or reservoirs, but in the few projects where a dam failure can result in major flooding and risks downstream of the dam this can be a very serious event. ERA and DWRM require dam safety measures to be undertaken and regular monitoring to be documented as part of preventing catastrophic dam breaks.

No serious dam breaks have been recorded in Uganda's hydropower industry.

Permanent waterway

Waterway safety is also important as several hydropower waterways go through populated areas (see Figure 7-7), and a failure can result in flooding of nearby and downstream houses and property. Importantly, the volume of uncontrolled flooding will typically be much smaller than for a dam break but can still cause damage and danger to people, depending on the measures put in place to minimise damage from such events.

Penstock pipeline breaks have been recorded in hydropower projects in Uganda, and forebay failure and headrace canal foundation failures have been recorded. These have resulted in damage but not loss of lives.



Figure 7-7: High-pressure penstock pipe at Nyamwamba Hydropower Project that is buried through a settled area on the way to the power station in the background (photo by GET FiT Uganda).

Other risks

Several other emergencies may occur in the Electricity Supply Industry, including:

- Substantial oil or fuel spills at hydropower projects, substations for transmission or distribution lines as well as at fossil fuel thermal power plants.
- Fire that gets out of control, for instance at co-generation plants where large volumes of combustible bagasse are stored for use in the boilers.
- Fire outbreaks (transformer explosion) within substations.

7.3.4 Pollution and Noise

Construction activities will result in noise from machinery and construction activities as well as dust and air pollution from vehicles, machinery and

excavations. This will affect both workers and local people. Generation projects, particularly hydropower, typically involve more comprehensive and longer-term construction works and hence will likely result in more noise and air pollution than transmission and distribution projects.

During operation, transmission and distribution lines may result in low-level noise. Generation projects may be associated with much higher noise levels, including at night-time due to the 24-hour operations of most generation projects. Important sources of noise include the powerhouse and tailrace of hydropower projects and the combustion facilities of thermal power plants. Solar PV projects do not generate substantial noise during operation.

Air pollution during the long-term operation phase is typically associated with combustion of fuel at thermal power plants that result in gaseous emissions. Fossil fuel plants operating on heavy fuel oil or diesel as well as co-generation plants burning biomass (mainly bagasse from sugar factories) are producing air pollutants. The air pollution typically occurs in the form of particles of various sizes (sooth) and various gases such as sulphur dioxide (SO_2), nitrogen oxides (NO_x), carbon dioxide (CO_2), and carbon monoxide (CO). The air pollution will result in disturbance and potential air quality related health problems at local level. Hydropower projects generally result in minimal air emissions beyond the limited use of vehicles and machinery used during operation.

Noise and air pollution can result in health problems for workers and local people, including general disturbances, reduced hearing ability due to noise, respiratory tract problems due to air pollution and dust.

Forms of pollution covered in other sections of this report are not included in this subsection, such as water pollution covered in Section 4 and other pollution and waste covered in Section 8.

7.3.5 Disease

Vector-borne diseases can increase following hydropower projects can expand availability of water bodies through inundation. Hydropower reservoirs and intake ponds can increase areas available for disease

vectors such as mosquitoes carrying the malaria parasite or for snails that harbour the bilharzia parasite (schistosomiasis). It will be important to monitor the local community disease prevalence when creating significant reservoirs as basis for tracking any trends and identifying potential measures required to manage an increase in disease prevalence.

Where a substantial workforce is employed by a project, there is often disposable cash among workers that is spent in the local community, including paying for sex and increasing risks of communicable diseases such as sexually transmitted diseases. Diseases such as HIV/AIDS are still causing substantial problems and costs for people (UAC, 2020).

7.3.6 Population Influx

Large construction projects tend to attract persons seeking employment or other economic opportunities associated with such projects. The impacts associated with population influx are discussed in Sections 6.3 and 6.4.

7.3.7 Air Quality and Substitution of Biomass and Kerosene with Electricity

Where electricity replaces more polluting forms of energy, there are positive impacts from the increased electricity use. Electricity is gradually replacing biomass for cooking in higher income households and institutions, but biomass in the form of charcoal or fuelwood is still the dominant source of energy for cooking. Where the biomass is replaced, this results in reduced air emissions in the form of particles (sooth) and various gases (e.g., carbon monoxide, nitrogen oxides, sulphur dioxide, organic air pollutants). Therefore, the switch from biomass to electricity improve indoor air quality and the conditions of those cooking, which in turn reduces health risks and premature death associated with air pollution (e.g., various respiratory problems, and lung cancer).

Similarly, where the provision of electricity results in the replacement of kerosene lamps for lighting, similar improvements in indoor air quality take place and will reduce risks of health problems related to air quality. Replacement of kerosene for lighting may be from multiple sources of

electricity, including small solar home systems, while electricity for cooking is typically from the national grid.

7.4 Responses

7.4.1 Avoidance and Minimising

The most important response is to try to avoid and minimise health and safety risks both for workers and for surrounding communities, institutions, and businesses.

In terms of surrounding communities, institutions, and businesses, the risks and adverse impacts are first and foremost avoided and minimised through site selection of the Electricity Supply Industry projects and the technological solutions selected to avoid and minimise risks, and then designing, constructing, operating, and maintaining the installations in accordance with good practice.

Opportunities for site selection are substantially constrained for hydropower projects because these need to be located on a river and only a very small number of sites along rivers have the combination of sufficient water and sufficient elevation difference to make hydropower economically viable. By contrast, solar PV projects have substantially more flexibility in site selection because the solar irradiation is much more evenly spread across a larger area. Therefore, multiple locations can be economically viable to develop, and it is easier to avoid populated areas where health and safety risks may become more prevalent.

Avoiding and minimising health and safety risks for workers are less driven by site selection and more influenced by appropriate construction and operation methods and equipment, undergoing health and safety training, undertaking risk assessments for specific work operations, implementing measures identified as necessary precautions during risks assessments, and always using appropriate personal protective equipment.

There is important legislation and requirements developed by the Ministry of Gender, Labour and Social Development (MGLSD), including the

Occupational Safety and Health Act (2006), the Employment Act (2006) and other employment-related acts, associated regulations, policies, and guidelines.

As part of the longer-term operation and maintenance phase, there is important preventative monitoring and maintenance that needs to be undertaken, which may also identify the need for corrective actions. For instance, a high-pressure water pipeline (penstock) at a hydropower project requires regular internal and external inspection to check for movement of or stresses on the pipe, corrosion, damage, leakage, etc. that can eventually result in a penstock burst, which can result in abrupt, serious flooding of nearby households. Should problems be identified, these need to be documented and understood before appropriate actions are taken.

7.4.2 Mitigation

Several mitigation measures need to be implemented to ensure the health and safety of workers and local people. There are, however, no measures that will guarantee that serious injuries or fatalities do not occur.

A key measure is to undertake risk assessments to identify and assess the risks that require management. Risk assessments are needed in relation to community risks as well as risks to workers. Risk assessments need to be undertaken regularly in a project as planning and implementation progress, and these will range from early planning stage risk assessment to identify important risk areas to more detailed risk assessment for specific activities or work operations as plans are detailed and implementation ongoing. These assessments will identify specific mitigation measures that need to be undertaken before activities or work operations can be undertaken as well as measures during implementation of works or activities.

The approvals of lead agencies, for instance the Registration of Workplace and permits for lifting equipment and other equipment by the Occupational Safety and Health Department, contain several conditions and requirements related to health and safety to ensure risks are managed. ERA follows up to ensure that all workers exposed to high noise

dosage undertake routine (annual) audiometric tests to monitor the impact of noise on hearing acuity.

The implementation of a workers' grievance management mechanism at each project will also assist in identifying health and safety issues that are raised by the workers. These grievances require timely resolution and potentially temporary stopping of the work until corrective measures have been undertaken to ensure the workplace is safe.

An Emergency Preparedness and Response Plan is required if there are risks of emergencies such as fire, flooding, landslides, or substantial spills of hazardous materials either during construction or during operation. The emergencies can be directly related to the project (e.g., dam breach, penstock burst, power station fire) or caused by non-project factors (e.g., flooding or landslide resulting from heavy rainfall). Many projects have Emergency Preparedness and Response Plans, but the plans are at times too generic to provide practical descriptions of actions to be taken. Some projects also undertake emergency drills.

In addition to the measures mentioned above, the following are examples of mitigation measures implemented by Electricity Supply Industry projects:

1) Induction, training, and provision of safety equipment for new employees to ensure these are well-equipped to identify and respond to health and safety risks.
2) Awareness raising among local communities regarding project-related risks, ranging from construction activities, traffic, flooding, electrocution, communicable diseases, etc.
3) Some projects also support or offer HIV/AIDS testing, counselling, and treatment for both workers and community members and work with health authorities in such efforts.
4) River diversion (coffer dam) procedures at hydropower projects that include water level monitoring during works to trigger evacuation from the construction pit if the water reaches a certain level around the pit.

5) Installation of penstock isolation valve at hydropower projects that stops water flowing into the penstock in case of a penstock burst.
6) Installation of crossing points over open headrace canals at hydropower projects, fencing of headrace canals and covering parts of headrace canals with concrete slabs to minimise risks of persons falling into the canal.
7) Noise reduction measures at hydropower projects, for instance internal and external insulation of the powerhouse, or installation of rubber mats at the tailrace.
8) Installation of systems that sound an alarm when water starts spilling from a dam or a spillway and thereby warn people about abrupt increases in the river flow/water level.
9) In rare cases the project developer for a hydropower project has been requested to immediately stop construction works due to unsafe working conditions (e.g., risk of fall from height, risk of rock fall onto the workplace), and only restart works after confirmation and acceptance that necessary corrective measures have been undertaken.
10) The Electricity Safety Code requires that any incident that occurs is reported to ERA.

The measures listed above as responses are typically documented in an Occupational Health and Safety Plan, a Community Health and Safety Plan, and associated procedures.

To incentivise the switch from the use of biomass for cooking to using cleaner energy in the form of electricity, there is a lower priced "cooking tariff" for electricity as part of differentiated tariff levels.

7.5 Recommendations

Health and safety risks unfortunately result in serious incidents and fatalities from time to time. This has been recorded in all three segments (generation, transmission, and distribution). The information availed by project developers and owners about serious incidents and fatalities varies substantially. Some incidents are not reported, and the reporting

format makes it difficult to compare data over time and meaningfully track any trends. This also weakens the basis for understanding what can go wrong and how best to prevent future serious incidents and fatalities.

7.5.1 Policy

1) The DWRM, in collaboration with ERA, should develop more specific requirements and supporting guidance for dam safety and safety at waterways.

7.5.2 Implementation and Actions

1) Reporting on fatalities and serious incidents: Project developers and owners should improve notification of and reporting on fatalities and serious incidents across all three segments (generation, transmission, distribution) for workers and for non-worker persons (e.g., community members, trespassers). Minimum requirements for the reporting should be clarified by the OSH Department (MGLSD) in collaboration with ERA.

2) Headrace canal fatalities: Hydropower developers should develop a headrace canal procedure to minimise future drowning incidents in the headrace canals. The procedure should include, among other things, undertaking regular awareness raising on headrace canal risks in communities concerned, undertake frequent monitoring along the canal, provide community crossing points in locations prioritised by local people, install physical barriers in areas with easy access to the open headrace canal (e.g., fencing, or concrete slab), and provide safe water collection points if the headrace canal is used as a water source for local people.

3) Penstock burst: Hydropower developers with penstock pipes going through settled areas should revise their Emergency Preparedness and Response Plans to more specifically cover risks and responses in the event of a penstock burst.

7.6 References

UAC (2020). *The National HIV and AIDS Strategic Plan 2020/21-2024/25. Ending the HIV and AIDS epidemic: communities at the forefront*. Uganda Aids Commission (UAC), Kampala.

Unclassified

WASTE AND POLLUTION



Hazardous waste stored inappropriately at a hydropower project during construction in Kasese District (photo by GET FiT Uganda).

Unclassified

WASTE AND POLLUTION



Hazardous waste stored inappropriately at a hydropower project during construction in Kasese District (photo by GET FiT Uganda).

8 WASTE AND POLLUTION

8.1 Introduction

8.1.1 Background

Overall, the electricity sector industry in Uganda is dominated by renewable, clean energy sources and is not associated with substantial levels of waste generation or pollution. Nevertheless, the waste and pollution generated require careful management, and this section describes the pressures resulting in impacts from waste and pollution in the electricity supply industry. Mitigation measures and other responses implemented in the sector are also discussed.

This section does not cover greenhouse gas emissions and climate change, which are covered in Section 9. Water pollution is also discussed in Section 4.

8.1.2 National and International Legal Frameworks

Waste and pollution are mainly managed by the National Environment Management Authority and the Ministry of Water and Environment. Important national legal frameworks in terms of pollution and waste include:

1) Constitution of the Republic of Uganda, 1995, as amended.
2) National Environment Act, 2019.
3) Water Act Cap 152 (currently under review).
4) Occupational Safety and Health Act, 2006.
5) Public Health Act, CAP 281.
6) National Environment (Environmental and Social Assessment) Regulations, 2020.
7) National Environment (Standards for Discharge of Effluent into Water or Land) Regulations, 2020.
8) National Environment (Waste Management) Regulations, 2020.

9) National Environment (Oil Spill Prevention, Preparedness and Response) Regulations, 2020.
10) National Environment (Management of Ozone Depleting Substances and Products) Regulations, 2020.
10) National Environment (Noise Standards and Control) Regulations, 2003.
11) National Environment (Air Quality Standards) Regulations, 2024.
12) Water Resources Regulations, 1998.
13) Water (Waste Discharge) Regulations, 1998.

In terms of international legal instruments, the Stockholm Convention on Persistent Organic Pollutants, 2001, is particularly important for the electricity sector due to the presence of PCB at some installations.

8.2 Drivers and Pressures

Uganda's electricity needs are one of the drivers resulting in significant pressures on natural resources. Among these pressures is the generation of increased levels of waste and pollution to air, water and soils in a manner that may pose a threat to the environment and people.

All aspects of the electricity supply chain, from generation to distribution and supply, may involve the introduction of pollutants into the environment of varying magnitude and significance. The key sources of pollution in the electricity supply industry arise from the use of natural resources for electricity generation, transmission, and distribution of electricity. The natural resources used may result in air emissions, hazardous and non-hazardous materials (wastes) that may enter water or soils, and diversion of water may result in accumulation of pollution (reduced dilution) and smothering of riverine habitats. The pollution may include particularly harmful substances, for instance, persistent organic pollutants (POPs) such as polychlorinated biphenyls (PCBs).

The main pressures include activities and contexts such as:

- Generation of non-hazardous waste at most installations, including organic waste, plastics, paper, scrap metal, etc.
- Generation of hazardous waste from machinery and equipment, including oil waste, electronic waste, and treated wooden poles.
- Air emissions from construction activities, vehicles as well as operational emissions from thermal power plants burning fossil fuels or biomass.
- Effluent releases and sediment discharges into water bodies (see Section 4).
- Water abstraction for hydropower generation that reduce dilution of any pollution along the diverted river section.
- Vandalism and theft from installations that result in damaged equipment that need to be disposed of.
- Need for change to clean energy such as replacement of fossil fuel in electricity generation and switch to a renewable source.

Figure 8-1 below summarises the main driver, the resulting pressures, the main state of environment components that may be affected by the pressures, the resulting impacts, and some main responses. Information on the state of the environment and impacts is summarised in Section 8.3 and responses are presented in Section 8.4. Recommendations are summarised in Section 8.5.

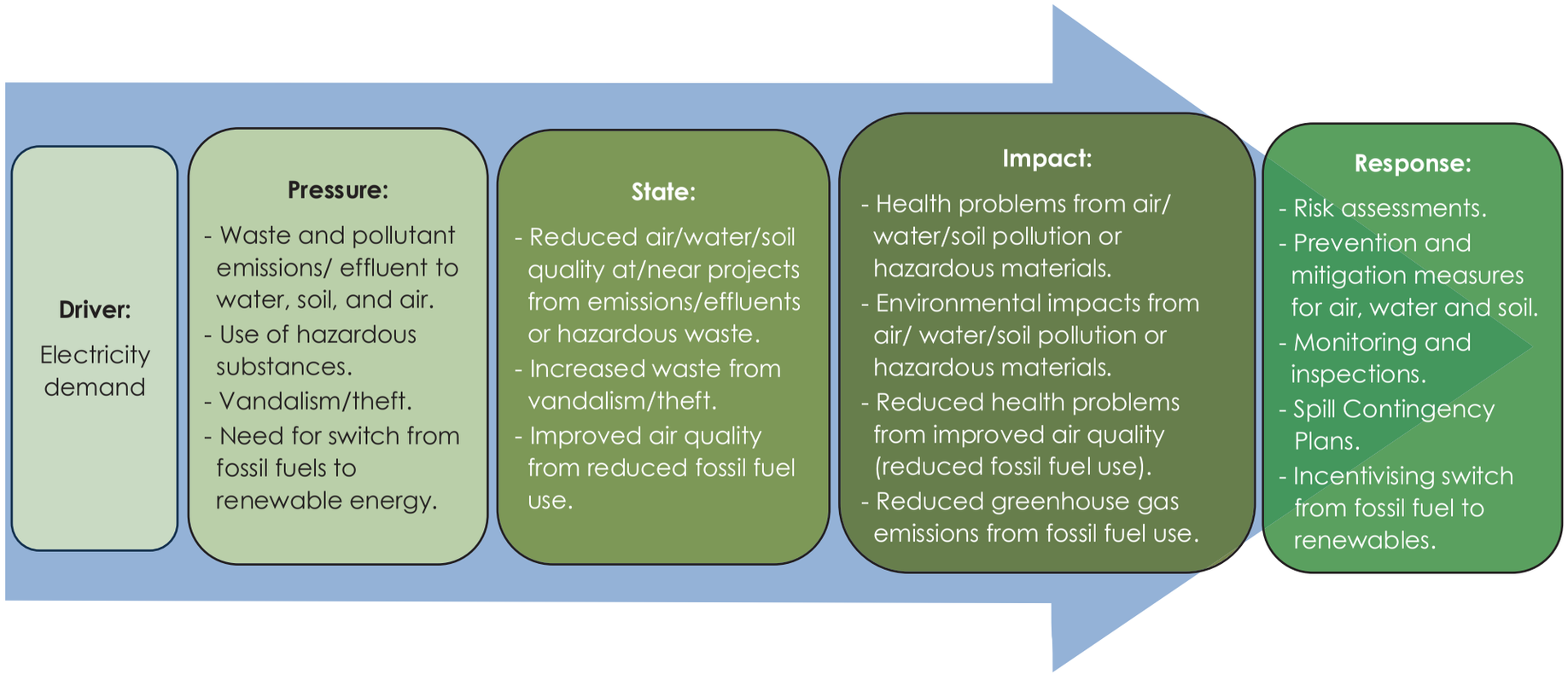


Figure 8-1: Key elements in the DPSIR model summarising the main pressures, states, impacts, and responses concerning the electricity sector's effects on waste and pollution.

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8.3 State and Impact

8.3.1 Air Emissions and Pollution

Electricity generation can be a substantial source of air pollutants, particularly where fossil fuels and biomass are used to produce electricity. The magnitude and nature of air emissions depend greatly on factors such as fuel, type of combustion, operating practices, and emission control measures being implemented.

Point Source Emissions

Point emission sources are discrete, stationary and identifiable sources that release pollutants into the atmosphere. Point source emissions are the most significant emission source in electricity generation. The primary emissions through point sources are nitrogen oxides (NO_x), sulphur dioxide (SO_2), carbon monoxide (CO), carbon dioxide (CO_2), and particulate matter (PM).

Point source emissions originate from thermal power plants running on fossil fuels (heavy fuel oil, and diesel) and biomass (co-generation plants). While specific emissions data are not available, the energy produced from these sources indicate a substantial reduction in emissions from fossil fuel since 2010 to today, a period that has seen heavy fuel oil drop from 24% of the generation to approximately 1% (see Figure 2-22, page 59). The 1% is mainly to maintain back-up capacity. The co-generation capacity has increased by more than four times between 2013 and 2023 and currently has installed approximately 1.5 times the fossil fuel capacity and represent more than four (4) times the annual generation. The expansion of co-generation based on bagasse as fuel will have increased air emissions.

With approximately 92% of the grid electricity in Uganda produced from hydropower and an additional 1.7% from solar PV, the electricity generation represents overall low air emissions.

Fugitive Emissions

Fugitive source air emissions refer to emissions that are distributed spatially over a wider area and not confined to a specific discharge point, or the term refers to irregular releases from equipment or installations. Fugitive emissions mainly originate in operations where exhausts are not captured and passed through a stack.

There are likely very limited fugitive air emissions within the Electricity Supply Industry in Uganda, for instance minor emissions of volatile organic compounds (VOCs) from fossil fuels plants and co-generation plants as well as particulate matter (PM) emissions.

Emission of SO_2

Fossil fuels (heavy fuel oil, and diesel) and biomass contain sulphur that is released as the gas sulphur dioxide (SO_2) during combustion. SO_2 is associated with several adverse effects on the respiratory system. For example, short-term exposure to SO_2, ranging from 5 minutes to 24 hours, will cause respiratory effects and increased asthma symptoms. Exhaust emissions of sulphur oxides are directly related to the sulphur content of the fuel. HFO plants in Uganda typically use low-sulphur-content fuel.

Currently, there is only one operational HFO power plant (Namanve Thermal Power Plant) for grid supply, which is running at 14% capacity (7 MW). However, during an emergency, this plant can be dispatched at full capacity. As mentioned above, there has been a significant reduction in energy dispatch from HFO plants in Uganda since 2010 (see Section 2.8.6 above).

Some results from air emission measurements at the Namanve Thermal Power Plant are included in Table 8-1.

Table 8-1: Results of stack emissions measurement of Namanve Thermal Power Plant in 2012 and 2018.

Year	CO (ppm)	NO (ppm)	NO_2 (ppm)	NO_x (ppm)	SO_2 (ppm)
2012	37.43	823.43	8.29	832	277
2018	69.5	667	1	668	223

Source: ERA Database, 2023.

Emission of NOx

During the combustion, nitrogen in HFO, in biomass and that is in the air react to form oxides of nitrogen – namely nitric oxide (NO) and nitrogen dioxide (NO_2). Of these two, NO_2 is linked with several effects on the respiratory system due to its contribution to the formation of ground-level ozone and fine particle pollution.

Emission of particulate matter

Particulate matter is the most common fugitive emission from the construction and operational processes such as flying bagasse related to combustion, transport and open storage of solid materials, and exposed soil surfaces, including unpaved roads.

The available data on the emission of particulate matter from power plants is not well documented. More systematic monitoring and air quality assessments are required to address current data gaps.

8.3.2 Solid Waste and Hazardous Materials

Generation, transmission and distribution of electricity result in significant amounts of waste materials, which can either be non-hazardous or hazardous depending on the properties of the materials. Several materials used in the electricity supply industry are due to their intrinsic and extrinsic properties considered hazardous.

Proper management of solid waste and hazardous materials is required to avoid and minimise pollution of the environment that is also likely to cause or aggravate damage or nuisance to human health.

Solid Waste

The construction phase typically generates larger volumes of waste and these tend to be reduced substantially during the operational phase. Decommissioning may also result in substantial volumes of waste, for instance decommissioning of sections at substations during rehabilitation or upgrading.

Solid waste generation during the construction phase mainly includes:

a. Excavated materials
b. Construction off-cuts
c. Packaging materials (e.g., paper, plastic, wood)
d. Organic waste from food preparation
e. Sanitary waste from construction workforce

The solid waste generated during operation typically includes:

a) Oil-contaminated materials (rags),
b) Ash (for biomass power plant)
c) Sludge from heavy fuel thermal power plants.
d) Metals and electronic waste (e.g., broken conductors, insulators, decommissioned and obsolete installations from replacement or maintenance activities for power lines and substations).
e) Poles treated with preservatives such as creosote.

Vandalism and damage due to theft or attempted theft of materials typically increase the volumes of waste generated in the sector.

Hazardous Materials and Hazardous Waste

Hazardous materials used in electricity sector projects and hazardous waste generated include petroleum products such as oils and fuels, gases, chemicals used for utility poles preservation and other painting-related chemicals. Herbicides are occasionally used for controlling vegetation to supplement manual clearing.

Polychlorinated Biphenyls (PCBs)

The electricity sector uses highly refined mineral insulating oils to cool transformers, capacitors, and other receptacles and also to provide electrical insulations. The mineral oils contain several chemicals that may contain polychlorinated biphenyls (PCBs), which were more commonly used in the past but are not allowed in new equipment and oils.

PCBs are organochlorine compounds with the formula $C_{12}H_{10-x}Cl_x$ (ATSDR, 2021). They are pale yellow hydrophobic viscous liquids with a very low water solubility, but highly soluble in most organic solvents, oils and fat. PCBs have low vapour pressures at room temperature, very high thermal conductivity, high flash points and good dielectric properties. In addition to the above properties, PCBs are resistant to acid bases, oxidation, hydrolysis and temperature change. These properties mean that the PCBs do not easily degrade and are widely used in many industries, including electricity supply industries as dielectric and coolants for electric equipment.

Notwithstanding the good electric properties, PCBs have high environmental toxicity, and they are classified as persistent organic pollutants known to be carcinogenic. Because PCBs do not degrade easily, these substances can remain in the environment for long periods, become widely distributed geographically, accumulate in the fatty tissue of humans and wildlife, and can have very harmful impacts on human health and the environment (Faroon *et al*., 2001).

Therefore, PCBs are one of the prohibited chemicals in Uganda according to Schedule 8 of the National Environment Act, 2019, and the Stockholm Convention on Persistent Organic Pollutants (POPs) from 2001 banned PCBs. Uganda ratified this Convention on 20 July 2004, and it came into force on 18 October 2004. The production of PCB was globally banned in 2004 and the complete elimination of the use of PCB in equipment such as transformers was staggered up to 2025.

8.3.3 Impacts on Water Quality

There are multiple impacts on water quality in the electricity sector. These have been discussed in Section 4 and are not repeated here.

8.3.4 Greenhouse Gas Emissions

Electricity generation based on fossil fuels is an important source of greenhouse gas emissions in many countries. Uganda has used heavy fuel oil and diesel, and combustion of these fuels result in air pollution, including greenhouse gas emissions (e.g., CO_2). Greenhouse gas emissions contribute to global warming and climate change.

Since 2010, Uganda has substantially reduced the reliance on fossil fuels for electricity generation and replaced heavy fuel oil and diesel with renewable energy, mainly hydropower that now is generating approximately 92% of the grid electricity in 2023. Fossil fuel has gone from approximately 24% of the electricity generation in 2010 to just above 1% in 2023. The rest is made up by co-generation (bagasse) and solar PV.

Co-generation plants are another source of thermal power but instead of burning fossil fuels the co-generation plants in Uganda typically burn biomass in the form of bagasse. Biomass can be considered as a renewable source if the biomass is produced sustainably and there should not be net greenhouse gas emissions.

Sulphur hexafluoride gas (SF_6) is mainly a synthetic industrial non-toxic, non-flammable inert gas. In the Electricity Supply Industry, it is used as a gaseous dielectric medium for high-voltage circuit breakers, switchgear and other electrical equipment and it normally replaces oil-filled circuit breakers. In addition, under high pressure, SF_6 is used as an insulator in gas-insulated switchgear because it has a much higher electronegativity and density.

At the same time, SF_6 is one of the most potent greenhouse gases. The global warming potential is 23,900 times higher than that of carbon dioxide, compared over 100 years. The gas is inert in the troposphere and stratosphere and therefore extremely long-lived, with an estimated atmospheric lifetime of 800 – 3,200 years (IPCC, 2013). Volumes of this gas are typically small, and the risks of leaks are considered small.

There are also ozone depleting substances that are also very potent greenhouse gases, for instance, hydrofluorocarbons (HFCs) and hydrochlorofluorocarbons (HCFCs). The volumes of these are also likely small but data on their presence and disposal in the sector have not been found.

8.4 Responses

8.4.1 Avoidance and Minimising

The most important response is to avoid and minimise waste and pollution in line with the principles of the mitigation hierarchy, also referred to as the waste management hierarchy in the context of managing waste. This hierarchy indicates an order of preference for waste management actions that is in line with the provisions in the National Environment (Waste Management) Regulations (2020) and international good practices.

Under Section 96 of the National Environment Act (2019), and Regulation 5 of the National Environment (Waste Management) Regulations (2020), a person who generates waste is responsible for its proper management in a manner that does not cause harm to human health or the environment. In that respect, ERA shall ensure that the electricity generation, transmission and distribution Licensee is required to have a waste management plan, following the waste management hierarchy that prioritises measures as follows:

1) prevent
2) minimise
3) reuse
4) recycle
5) energy recovery
6) responsible disposal.

The extent to which waste and pollution can be avoided and minimised is affected by the source of energy and technological solutions for generation projects (e.g., using dry transformers rather than oil-filled

transformers). During project planning and studies, the likely waste and pollution associated with the construction and operation of a project need to be identified, the risks assessed, and how to prevent, minimise and manage waste and pollution. Waste and pollution management plans need to be developed both by contractors and the project operator/owner. Regulation monitoring and maintenance are essential to ensure functional equipment and prevent spills or other pollution.

Hydropower tends to be relatively low risk in terms of waste and pollution during the long-term operation phase but will involve substantial volumes of waste during construction. Most of the construction waste will be non-hazardous, for instance, large volumes of excavated material and general waste (scrap metal, wood waste, plastics, etc.). Hydropower projects also involve the use of various petroleum-based products during construction and operation (e.g., hydraulic oils) that will be categorised as hazardous waste and require appropriate disposal through NEMA approved waste transport and disposal facilities. These aspects are typically checking during Annual Environmental Audits as per NEMA requirements. Dust is typically suppressed using water during the substantial earth-moving activities in the construction phase.

Fossil fuel-fired thermal power plants are associated with long-term waste and pollution challenges, including greenhouse gas emissions and local air pollution. The large volumes of fuel stored on-site are typically in areas with secondary containment and equipment for cleaning up any spills. The use of low-sulphur heavy fuel oil reduces local air pollution from sulphur dioxide (SO_2).

Co-generation plans (bagasse-fired) also result in local air pollution and the installation of electrostatic precipitators will reduce particulate matter emissions in the flue gas. The large volumes of effluent from the sugar factory complexes producing the bagasse used in the co-generation plant have increasingly been treated in effluent treatment plants to minimise water pollution (Figure 8-2).

Solar PV projects are generally associated with limited waste and pollution but there will be electronic and other hazardous waste that is

stored, transported and disposed of through NEMA licensed waste handlers.



Figure 8-2: The effluent treatment plant at Kakira Sugar Ltd. to treat thousands of litres of wastewater daily through multiple steps before water is released to the environment (photo by GET FiT Uganda, satellite image from Google Earth).

In addition to measures already being implemented, ERA will mainstream into its compliance monitoring and enforcement regime various requirements for emission and air quality monitoring programmes to provide information that will be used to assess the effectiveness of emissions management strategies and the level of risk to recipients nearby. Licensees should include the following elements in emission and air quality monitoring programmes:

1) Monitoring indicator parameters that reflect the pollutants of concern associated with the particular type of electricity project;
2) Documentations of baseline information for each monitoring indicator parameter;
3) Monitoring frequency;
4) Monitoring locations; and
5) Methods of analysing and interpreting information generated from the monitoring programme.

8.4.2 Mitigation

Several mitigation measures are implemented to mitigate adverse impacts from waste and pollution in the sector. Project approvals by NEMA, DWRM and ERA have conditions attached to mitigate and monitor pollution and waste, including appropriate disposal.

In the electricity sector, there are some specific and important issues that are being addressed such as PCBs and sulphur hexafluoride. These are briefly discussed below.

Polychlorinated biphenyls (PCBs)

As a party to the Stockholm POPs Convention, Uganda is required to eliminate the use of PCBs in equipment such as transformers, capacitors and other receptacles containing liquid stocks by 2025, which is reflected in the National Environment Act, 2019. The following actions are being taken in with Annex A, Part II of the Stockholm POPs Convention:

a) Make determined efforts to identify, label and remove from use equipment [transformers] containing greater than 10 per cent PCBs and volumes greater than 5 Litres;

b) Make determined efforts to identify, label and remove from use equipment [capacitors] containing greater than 0.05 per cent PCBs and volumes greater than 5 Litres; and

c) Make determined efforts to identify, label and remove from use equipment [other electrical receptacles] containing greater than 0.005 per cent PCBs and volumes greater than 0.05 Litres.

The sector is also required to promote measures to reduce exposure and risk to control the use of PCBs, such as the use of only intact and non-leaking equipment and only in areas where the risk from a release to the environment can be minimised and quickly remediated.

ERA is in the process of ensuring that licensees undertake testing of all transformers to ascertain the PCB presence in the sector. This is implemented through the distribution licensees and UETCL. According to Umeme Limited, the Clor-n-Oil 50ppm PCB screening kits (produced by DEXSIL Corporation UK) have been used to screen for PCB in the field. This test kit gives positive or negative colourimetric results on a scale of 50 ppm, that is, indicates whether the PCB content is below 50 ppm.

The current results from Umeme Limited show that of the 15,799 transformers that were tested, only 0.4% of the transformers (63 transformers) were contaminated with PCBs, of which there were fifty-eight (58) distribution transformers and at least four (4), possibly five (5), power transformers. The power transformers are in Rukungiri substation (1), Nakifuma substation (1), Bombo substation (2), and Mityana substation (1). In addition, a total of 6,160 litres of PCBs contaminated transformer oil have been recovered as of 2023 Umeme Limited. The oil was placed in sealable drums to minimise spillage and transformers for disposal using licensed hazardous waste handlers at Luweero Industries Limited.

In terms of management, all the fifty-eight (58) distribution transformers containing more than 50ppm of PCBs were recovered from the network,

washed, flushed and refilled with new oil without PCB. The transformers were retested before reinjection into the network. A PCB safe tag was appended to transformers which had negative results from the PCB test (see Figure 8-3). Further, ERA has allowed a capital expenditure recovery by licensees within the tariff for retro-filling the affected power transformer with PCB-free oil and for disposal of contaminated oils from the power transformers.



Figure 8-3: A transformer where the oil has been tested and found free of PCBs (photo by ERA).

ERA will support other distribution licensees by allowing costs related to testing and eliminating equipment containing PCB, in the tariff, to fully ascertain the PCB burden in the sector.

Sulphur hexafluoride (SF_6)

Given the high global warming potential and its implication on the climate, measures are needed to minimize leakages and emissions of the SF_6 into the atmosphere. ERAI intends to develop a monitoring framework where the amount of SF_6 used within the sector will be documented. As

part of the monitoring framework, the rate of leakages can be calculated from how much gas is being refilled.

Water quality

Section 4 above describes mitigation measures concerning water pollution and water quality.

Other measures

The implementation of a workers' grievance management mechanism and a community grievance management mechanism at each project will also assist in identifying waste and pollution issues that are raised by the workers or by the local community members. This can supplement other monitoring of waste and pollution.

An Emergency Preparedness and Response Plan (EPRP) is required if there are risks of emergencies such as fire, flooding, landslides, or substantial spills of hazardous materials either during construction or during operation.

A Spill Contingency Plan may replace an EPRP in terms of responses to spills as such a plan describes the response and removal procedures to control, contain and recover spills that may be harmful to the environment, workers, or local people. Spill clean-up equipment and kits need to be readily available at installations, and people need to be trained in the use of such equipment. Only then can projects respond to spills in line with Section 79 of the National Environment Act (2019) that requires necessary actions to stop further pollution and minimise impacts on the environment and human health. Most projects have at least basic kits available on-site in case of spills.

In addition to the measures mentioned above, the following are examples of mitigation measures implemented by electricity sector projects:

1) Induction, training, and provision of relevant equipment to control and clean-up spills.

2) Maintain waste registers to keep a record of all waste on-site. Maintain records of waste transfers and disposal, including certificates of destruction for hazardous waste.

3) Installation of hazardous materials and waste storage facilities on impermeable surfaces with bunding/secondary containment (see Figures 8-4 and 8-5) with a capacity corresponding to 110% of the total, potential stored volume of hazardous materials/waste. Testing that the facilities' surface and bunding are watertight.

4) Installation of sufficiently sized oil/water separators that collect drainage from all areas where oil leaks or spills are likely to occur (e.g., powerhouse and switchyard with transformers). Testing that the surfaces draining to the oil/water separator are watertight and that water poured on such surface drains to the oil/water separator as well as testing that the oil/water separator is watertight.



Figure 8-4: Fuel tanks in bunded facility during construction of a hydropower project (photo by GET FiT Uganda).



Figure 8-5: A hazardous materials and hazardous waste storage during operation of hydropower project (photo by GET FiT Uganda).

Starting with FY 2024/25, and in line with the National Environment Act, 2019, and the National Environment (Oil Spill Prevention, Preparedness and Response) Regulations, 2020, the sector will ensure that all spills are documented and reported, which shall include among others, the number and estimated volumes of oil spills, affected areas, root cause investigation carried out and corrective actions undertaken to prevent reoccurrence.

In addition, each generation, transmission, and distribution licensee shall prepare a spill response plan, which will address among others potential oil, chemical and fuel spills from electrical installations, and support infrastructures and capability to implement the plan shall be put in place.

8.5 Recommendations

Important waste and pollution issues in the electricity sector are typically related to hazardous waste (e.g., oil/petroleum-based products and electronic waste), water pollution and air pollution. The recommendations below are mainly concerned with these issues.

8.5.1 Policy

1) DWRM, in collaboration with ERA and NEMA, should develop more specific requirements and supporting guidance for specific hydropower facilities at risk of causing pollution, including sediment flushing from dams, releases from powerhouses, releases from switchyards, and the designs of oil/water separators (see also Section 4).

8.5.2 Implementation and Actions

1) ERA, in collaboration with NEMA and licensees, should eliminate PCBs from electrical installations in line with the Stockholm POPs Convention and the National Environment Act, in particular from transformers managed by UETCL and distribution companies.

2) NEMA, in collaboration with ERA and DWRM, should review existing hydropower facilities at risk of causing pollution, including sediment flushing, powerhouses, switchyards, and oil/water separators, and clarify requirements and improve arrangements where necessary (see also Section 4).

3) NEMA, in collaboration with ERA and DWRM, should review existing effluent releases and effluent treatment plants at co-generation projects, and clarify requirements and improve arrangements where necessary (see also Section 4). Similarly, a review of existing air quality monitoring should be undertaken to identify more systematic monitoring regimes that start filling existing data gaps.

4) ERA, in collaboration with NEMA, shall task each generation, transmission, and distribution licensee to develop a monitoring framework where the amount of sulphur hexafluoride (SF_6), which is an extremely potent greenhouse gas, is monitored and managed

appropriately in the industry, including to avoid and minimise leaks and document the use in the sector.

5) NEMA, in collaboration with ERA, should closely monitor the existence and use of ozone depleting substances, and ensure that prohibited substances are not used and these are phased out or the use restricted in line with national regulations on ozone depleting substances.

8.6 References

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Unclassified

CLIMATE CHANGE MITIGATION AND ADAPTATION



Switchyard of Nyamwamba Hydropower Plant following a flood event of River Nyamwamba in Kasese District (photo by Serengeti Energy Limited)

Unclassified

CLIMATE CHANGE MITIGATION AND ADAPTATION



Switchyard of Nyamwamba Hydropower Plant following a flood event of River Nyamwamba in Kasese District (photo by Serengeti Energy Limited)

9 CLIMATE CHANGE MITIGATION AND ADAPTATION

9.1 Introduction

Climate change due to human-induced global warming is the result of increasing greenhouse gas[8] (GHG) emissions and GHG concentrations in the atmosphere and is likely the most important environmental problem globally. Climate change causes serious environmental impacts, for instance changes in precipitation patterns, extreme weather events such as high temperatures, drought and flooding (UNMA, 2021), major reductions in the glaciers in the Rwenzori Mountains (Taylor *et al*., 2006), and rising Lake Victoria water levels (Khaki and Awange, 2021). Climate change represent risks to key sectors such as agriculture, water resources, electricity, in particular hydropower generation, and heath.

The National Climate Change Act (2021) defines "climate change" as "a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is, in addition to natural climate variability, observed over comparable time periods". The Act refers to "mitigation" as "efforts that seek to prevent or reduce the increase of atmospheric greenhouse gas concentrations by limiting current or future emissions and enhancing potential sinks for greenhouse gases". The Act defines "adaptation" as "adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects which moderates harm or exploits beneficial opportunities".

A grid emission factor (GEF) is the total amount of greenhouse gas emissions emitted for each unit of electricity generation by power plants in a country. It is commonly expressed in tons of carbon dioxide equivalent per megawatt hour of electricity (tCO_2eq/MWh) and is a fundamental parameter used to calculate emissions reductions from

[8] There are multiple gases contributing to human-induced global warming. The greenhouse gases listed under Annex A of the Kyoto Protocol to the United Nations Framework Convention on Climate Change are carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulphur hexafluoride (SF_6).

grid-connected power plants and energy efficiency or energy-saving projects of certain project types under the Clean Development Mechanism (CDM) or other carbon schemes.

9.2 National and International Frameworks

The National Climate Change Policy, 2015, provided guidance towards achieving Vision 2040 while transitioning to a low-carbon and climate-resilient economy. The National Climate Change Act, 2021, is, among other things, based on the UN Framework Convention on Climate Change (UNFCCC, 1992), the Kyoto Protocol (1997), and the Paris Agreement (2015), the latter which Uganda ratified in 2016, as well as the UN Sustainable Development Goal 13 on combating climate change. The Act informed the updated nationally determined contribution (NDC) in 2022. In fulfilment of Article 4 of the Paris Agreement, the updated NDC includes a target of a 24.7% reduction in GHG emissions in 2030 compared with the business-as-usual scenario (MWE, 2022b).

In addition to the frameworks specific to climate change, there are several sectoral policies of importance for the implementation of climate change adaptation and mitigation measures. These include policies covering renewable energy, forestry, agriculture, disaster preparedness and management, health, and others.

Importantly, the UNFCCC sets its ultimate objective as stabilising greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Through the development of the Energy Transition Plan (ETP), Uganda has set a target to reach net zero emissions in the energy sector by 2065. Continued electrification delivers around 40% of the energy sector emissions reductions needed to reach net zero after Uganda peaks its emissions in 2040 (IEA, 2023).

The key mitigation actions in the Electricity Supply Industry are renewable energy generation and reduction in transmission and distribution losses. These actions can lead to emission reductions of approximately 0.0003 $MtCO_2eq$ by 2030 (MWE, 2022b). Increasing generation while

minimising greenhouse gas emissions are important to achieve both climate and energy security goals.

9.3 Current Climatic Status

9.3.1 Rainfall

Uganda's climate is largely tropical with two rainy seasons per year for three quarters of the country, from March to May and from October to December. The northern part, which forms one-quarter of the country, lies outside the tropical belt and hence experiences only one rainy season, March to October (MWE, 2014).

The relatively humid and warm equatorial climate zone, and the topography, prevailing winds, and lakes and rivers cause large differences in rainfall and temperature patterns across the country (see Figures 9-1 and 9-2).

The location in the tropics and across the equator means that Uganda's weather and seasons are manly determined by the large-scale Indian Monsoon, the Congo air mass, the Indian Ocean Dipole, and the Inter Tropical Convergence Zone (ITCZ) systems (WBG, 2021).

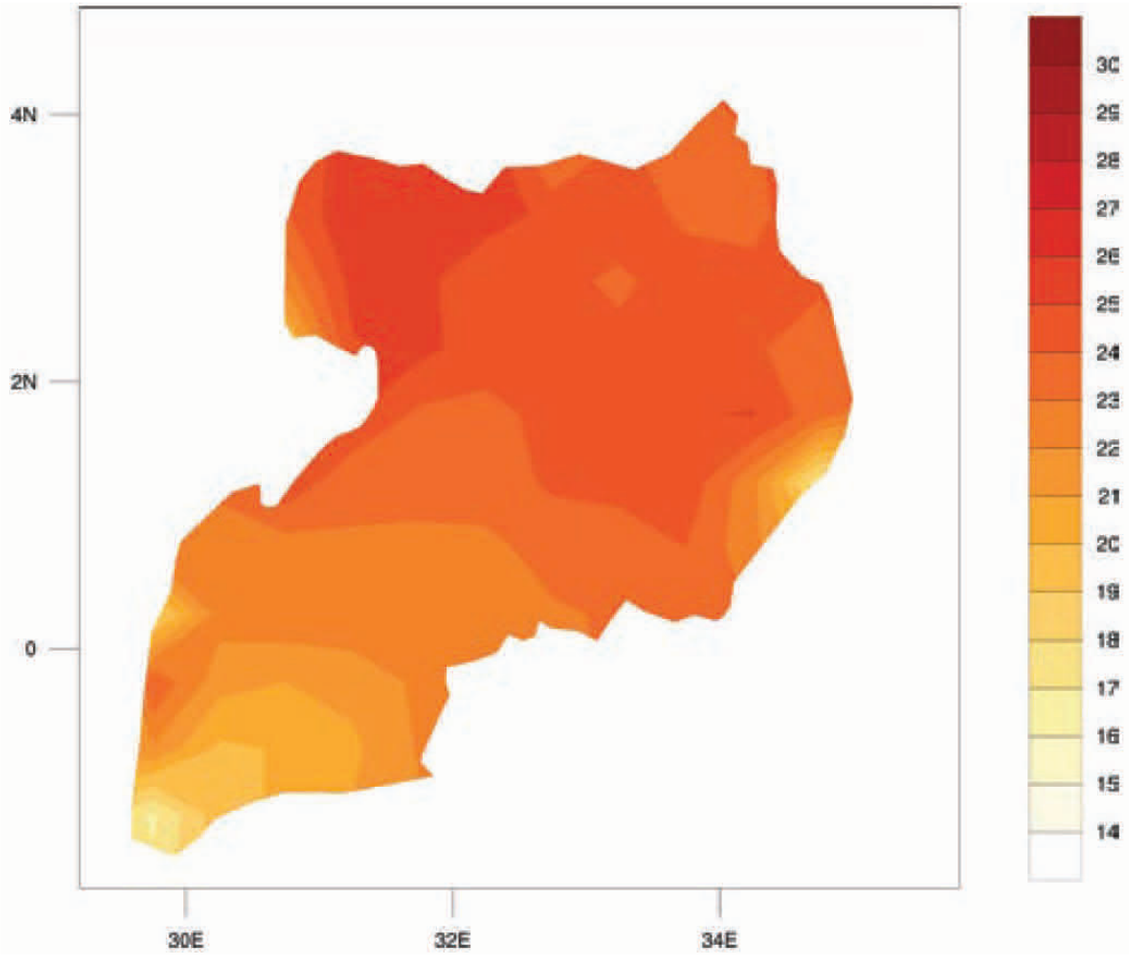


Figure 9-1: Average annual temperature 1991-2020 (source: WBG, 2021).

Uganda also experiences the El Niño Southern Oscillation (ENSO) phenomena, which are principal driving forces of intra-annual to inter-annual rainfall variability. The most pronounced impacts for Uganda are during the rainy season, September to December, when the El Niño is often equated to floods rather than La Niña which is often equated to droughts (MWE, 2014).

Southern Uganda can receive between 600 to 2,200 mm of rainfall annually, while the northern part of the country receives between 400 and 1,600 mm per year (see Figure 9-2). Precipitation patterns in Uganda indicate varied rainfall distribution with areas like Karamoja receiving the lowest amounts of rainfall of approximately 400 mm and areas around Lake Victoria and Elgon receiving the highest amounts of rainfall, up to 2,200 mm.

The annual rainfall trend between 1981 and 2021 over Uganda reveals that the mean annual rainfall exhibits a significant increasing trend over most parts of the eastern, northeastern, and in a few patches over southwestern regions of Uganda. Decreasing trends are visible over the northwestern, central west, and western parts of the country. The decreasing trends are mainly significant over parts of Mubende, Mpigi, and Sembabule (UNMA, 2021).

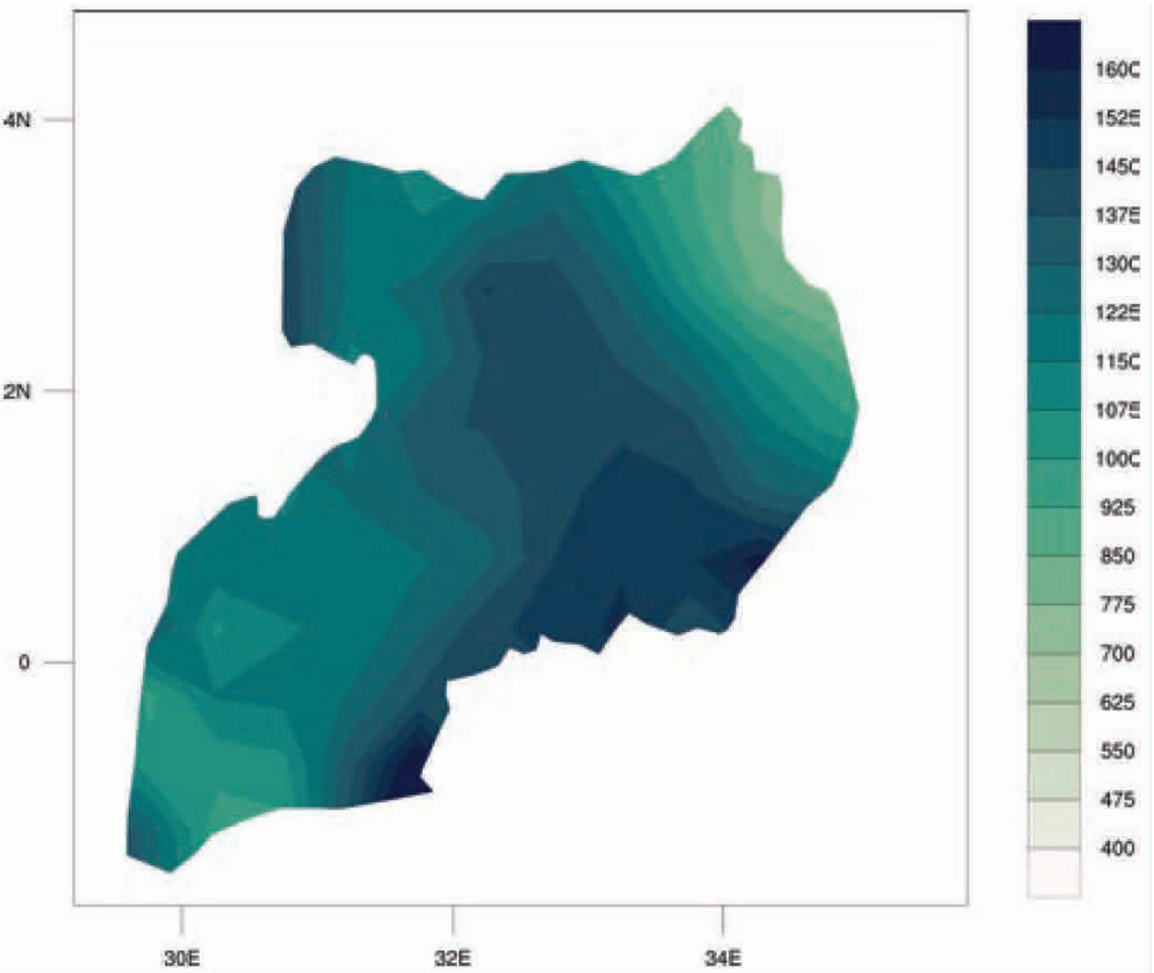


Figure 9-2: Average annual precipitation 1991-2020 (source: WBG, 2021).

The year 2019 received extremely high rainfall amounts during October-December compared to the long-term mean (see Figure 9-3). This might have contributed to the record-breaking rise in the Lake Victoria water level in 2019/2020 (UNMA, 2021).

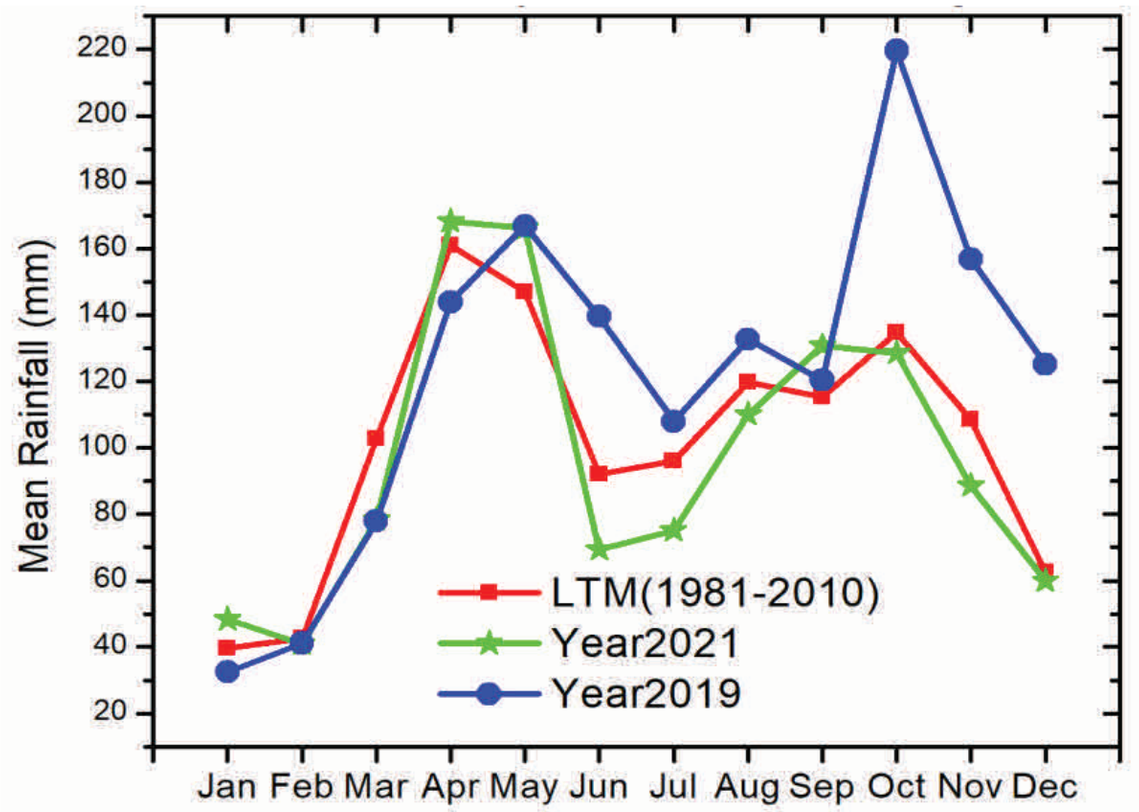


Figure 9-3: Mean annual cycle of rainfall (mm) for 2021 (green), 2019 (blue), and the climatology (red) with monthly values based on the reference period 1981-2010 for Uganda (source: UNMA, 2021)

9.3.2 Temperature

There has been a general warming trend in Uganda since the 1950s (UNMA, 2021; WBG, 2021; IPCC, 2022), as is illustrated in Figure 9-4. For example, all the 20 warmest years on record in Uganda were experienced in the last two decades. The warming rate over the past 72 years was found to be about 0.23°C/decade, compared to 0.25°C/decade over the last 31 years. The monthly temperature values in Uganda are increasing (UNMA, 2021). However, overall, Uganda experiences moderate temperatures throughout the year.

The country's diverse topography results in wide-ranging temperatures, from below 0°C in the ice-capped Rwenzori Mountains Range and Mt Elgon to more than 30°C in the northeastern areas of Gulu, Kitgum, and Moroto. The Rwenzori Mountain Range has permanent ice caps (glaciers), but due to rising temperatures the area covered by ice has

reduced dramatically over the past 100 years. The glaciers are projected to disappear by the 2030s or 2040s (Taylor *et al.*, 2006; UNMA, 2021).

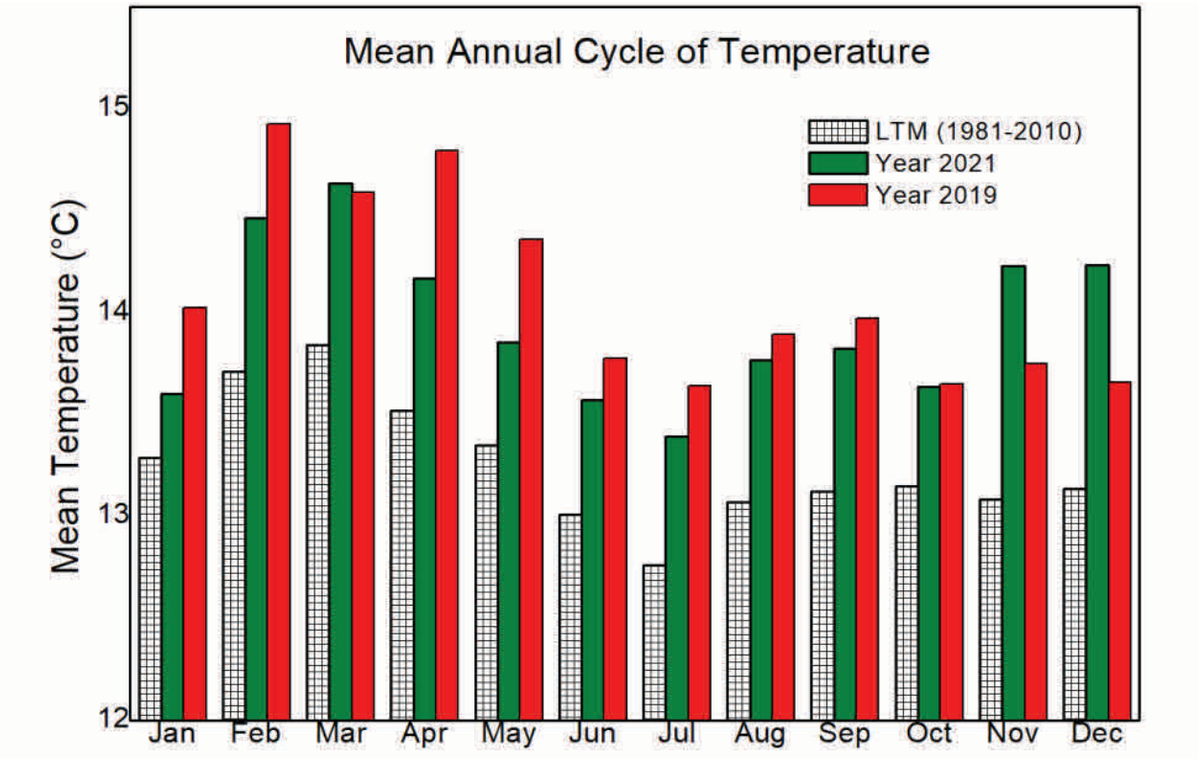


Figure 9-4: Mean annual cycle of temperature (°C) over Uganda for long-term mean, LTM (1981-2010), year 2021 and year 2019 (source: UNMA, 2021)

9.4 Climate Projections

9.4.1 Temperature

Increased temperatures are expected for East Africa and specifically for Uganda (IPCC, 2022). Under a high-emission scenario, monthly temperature change is expected to increase by 1.8°C for the 2050s and by 3.7°C by the 2090s (WBG, 2021). Increased temperatures will also impact increased aridity and the length and severity of the dry season (December to March).

Projected rates of warming are greatest in Uganda's coolest season: June to September, with temperatures expected to increase by 1.5 to 5.4°C by the end of the century. Hot days are expected to occur on 15–43% of days by the 2050s and by 18–73% of days by the end of the century. Nights that are considered 'hot' (>26°C) are expected to

increase more quickly than hot days (WBG, 2021). Temperature rise is projected to increase across all emission scenarios throughout the end of the century. Under a high-emission scenario, average temperatures will increase rapidly by mid-century. Across the seasonal cycle, temperature increases will be felt from September to January (see Figure 9-5).

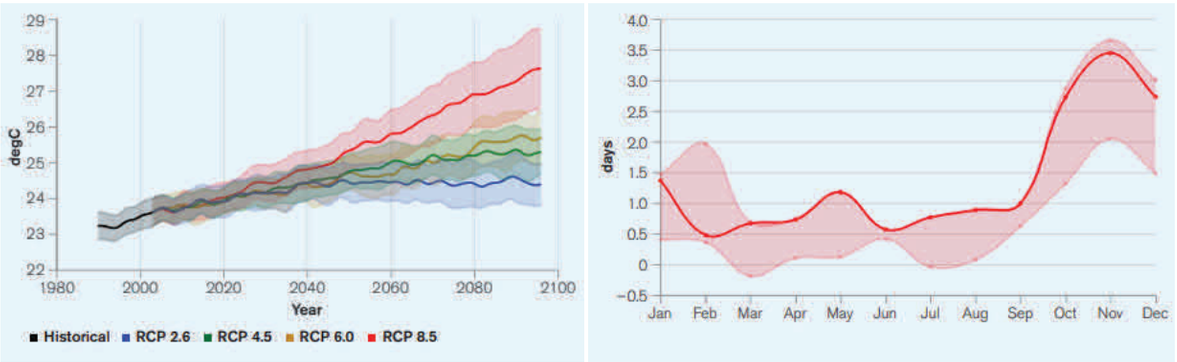


Figure 9-5: Historical and projected average temperature for Uganda from 1986 to 2099 and projected change in summer days, that is, days with Tmax> 25°C (source: WBG, 2021).

9.4.2 Precipitation

Under a high-emission scenario, monthly annual precipitation is expected to increase in some areas and decrease in others, notably the northern and northeastern areas. Future projections of precipitation are more uncertain than the projections for temperature (WBG, 2021; IPCC, 2022).

Rainfall is predicted to increase significantly and consistently for the western shores of Lake Victoria and the central western region; the Mount Elgon region; and the region extending from Mount Rwenzori to the southern parts of Lake Kyoga. This implies a higher likelihood of heavy downpours and an increased risk of floods in certain regions. The greatest change in the intensity and frequency of extreme rainfall events is likely to take place between the current and the mid-century period.

Overall, there is a likely increase in the number of consecutive wet days (daily accumulation of rainfall of 1mm per day) throughout the year. Additionally, the number of days with precipitation greater than 20mm will increase in each of the two rainy seasons in Uganda. Alongside heavy rainfall events, climate projections also indicate an increased risk of

droughts in some parts of Uganda. This can lead to water scarcity and impacts on hydropower generation.

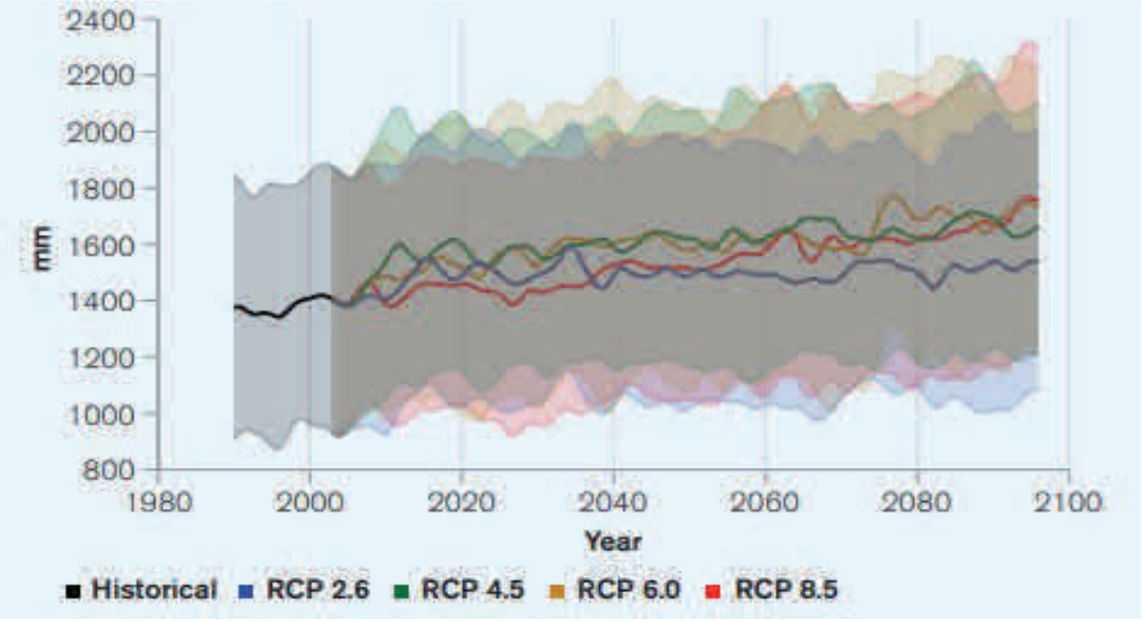


Figure 9-6: Predicted annual average precipitation in Uganda from 1986 to 2099 (source: WBG, 2021).

9.4.3 Climate Risks and Hazards

Uganda experiences natural disasters such as extreme weather events causing landslides, flooding, and drought. Some areas are particularly prone to risks, for instance the slopes of Mount Elgon and Mount Rwenzori. Extreme events leading to disasters such as floods, droughts, and landslides have increased over the past 30 years. An average of 200,000 Ugandans has been affected by disasters annually (WBG, 2021). Vulnerability is increased due to high poverty levels and dependence on sectors that can be particularly sensitive to climate change and extreme events, for instance agriculture, water resources, and fisheries.

9.5 Electricity Supply Industry Emissions

Uganda's GHG emissions have increased from 53.4 $MtCO_2eq$ in 2005 to 90.1 $MtCO_2eq$ in 2015. The emissions are mainly from land use, land use change and forestry with approximately 60% of total emissions. Agriculture contributed 27%, followed by energy (10.7%) and waste

(2.3%), see Figure 9-7. Electricity is only a part of the energy sector, which is dominated by biomass.

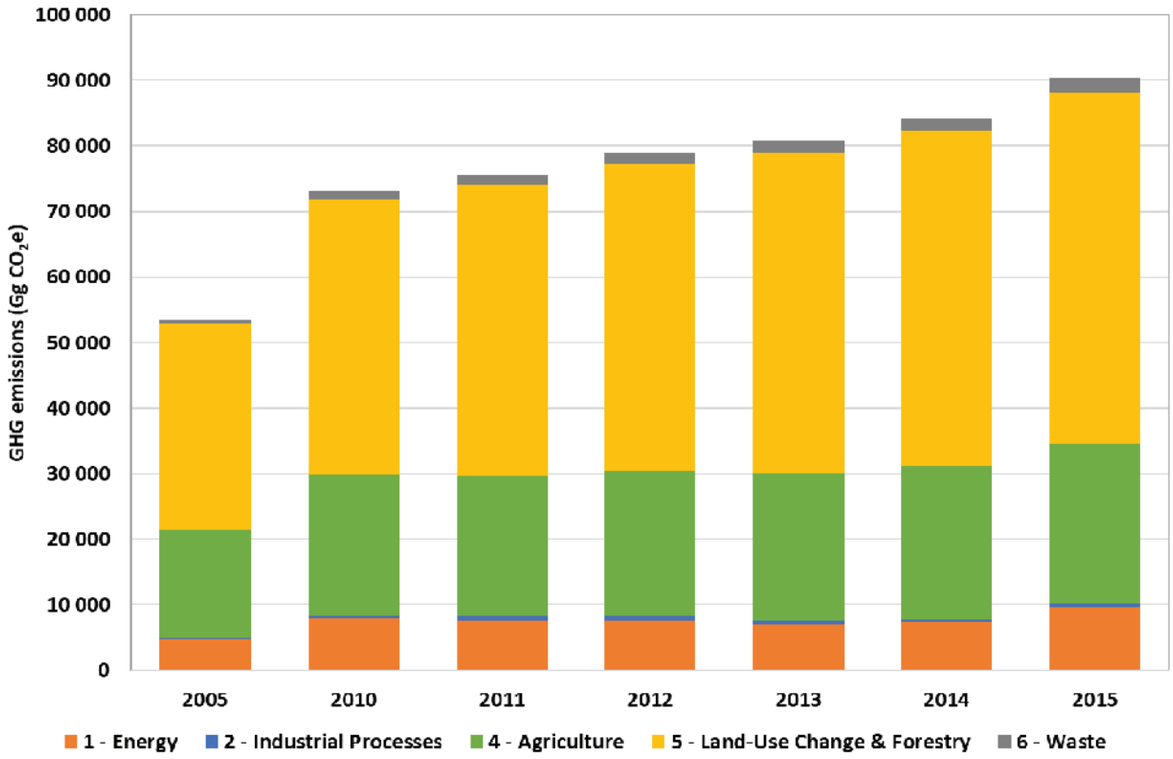


Figure 9-7: GHG emissions by sector for the period 2005-2015 (source: MWE, 2022b).

Increased renewable energy generation, reduction in transmission and distribution losses, and increased access to electricity are part of the measures to reduce GHG emissions compared with the business-as-usual scenario. The energy sector emissions (excl. transportation) under the business-as-usual scenario will increase from 5.7 $MtCO_2eq$ in 2015 to about 12.4 $MtCO_2eq$ in 2030. The mitigation actions included in the NDC have the potential to reduce GHG emissions in this sector by 18.8% to 10.1 $MtCO_2eq$ in 2030.

Globally, the Electricity Supply Industry accounts for the largest share (nearly 42%) of energy-related greenhouse gas emissions (IEA, 2022). This places the Electricity Supply Industry at the heart of the energy transition strategy of many countries. The emissions per kWh vary a lot across countries and from year to year, depending on the generation mix. Uganda has abundant renewable energy, and the electricity generation is approximately 98% from renewable energy (see Section 2.8).

Hydropower dominates (92%) with solar PV and bagasse co-generation adding approximately 7%.

Uganda's ambitious development agenda holds the promise that its future energy system will look very different from today, with universal access to electricity and clean cooking achieved by 2030, a key benchmark in Uganda's Energy Transition Plan (IEA, 2023). Spurred by economic transformation, industrialisation and modernisation, the nation's primary energy demand is set to increase threefold by 2050, enabling a measurable rise in living standards for all Ugandans and the growth of the nation's economy. Simultaneously converting to modern sources of energy while meeting rising demand implies a steep ramp-up in electricity use, and to a lesser extent oil. Electricity demand grows faster than any fuel in the Energy Transition Plan, with generation accelerating from 5 TWh today to 200 TWh in 2050 (IEA, 2023).

Different electricity generation technologies produce varying amounts of greenhouse gas (GHG) emissions, and the choice of generation technology therefore plays a decisive role in determining the Electricity Supply Industry's GHG footprint and whether the footprint will increase or reduce in the future. The GHG emissions of each technology depend on factors such as construction, operation, and decommissioning (IEA, 2020). Greenhouse gas emissions (GHG) are inherent to the operation of fossil fuel-based power plants. However, besides those power plants which directly emit GHG in the process, other technologies usually called "green" still result in some GHG emissions in the upstream and downstream stages of the process (power plant construction, obtainment of fuel, plant operation, waste treatment, etc.).

In power plants that run on renewable energies, such as hydropower, solar PV and wind, the GHG emissions are mainly attributable to their construction as well as the production and transport of materials and equipment. In exceptional cases, a hydropower reservoir can be responsible for substantial GHG emissions during operations (e.g., methane and CO_2 from decomposing organic matter in the reservoir). It must be emphasised that GHG emissions from different technologies vary substantially between projects as well as between different estimates or studies. For instance, studies have estimated that for every kWh of

electricity generated, a solar PV system results in between 60 and 150 grams of CO_2 (depending on where the solar panels were manufactured), and a wind turbine between 3 and 22 grams. Releases from fossil fuel plants are typically many times greater.

Given that Uganda largely relies on hydropower, emissions from electricity generation are relatively low even if not systematically quantified. Emissions from thermal power plants reached a peak of 350 Gg CO_2eq in 2010. In subsequent years it declined reaching a record low of 1.3 Gg CO_2eq in 2013 before rising again to 123.5 Gg of CO_2eq in 2017. Table 9-1 presents estimated emissions from the Electricity Supply Industry.

Table 9-1: Emissions from the Electricity Supply Industry as of 2017 (source: MWE, 2022a).

	Emissions (Gigagrams)						
	CO_2	**CH_4**	**N_2O**	**NO_x**	**CO**	**NMVOCs**	**SO_2**
Electricity generation	122.77629	0.00497	0.001	0.2353	0.02502	0.00381	0.82

*NMVOCs: Non-methane organic volatile compounds

Uganda imports SF_6, which is used as an insulator in the switch gears in the power substations (Figure 9-8) and is also an extremely potent greenhouse gas. Some of the SF_6 is used for refilling leaked circuit breakers and filling the circuit breakers which are bought without SF_6. Currently, there is no system to determine how much SF_6 is used for refilling switch gears and emissions related to its use are not accounted for.

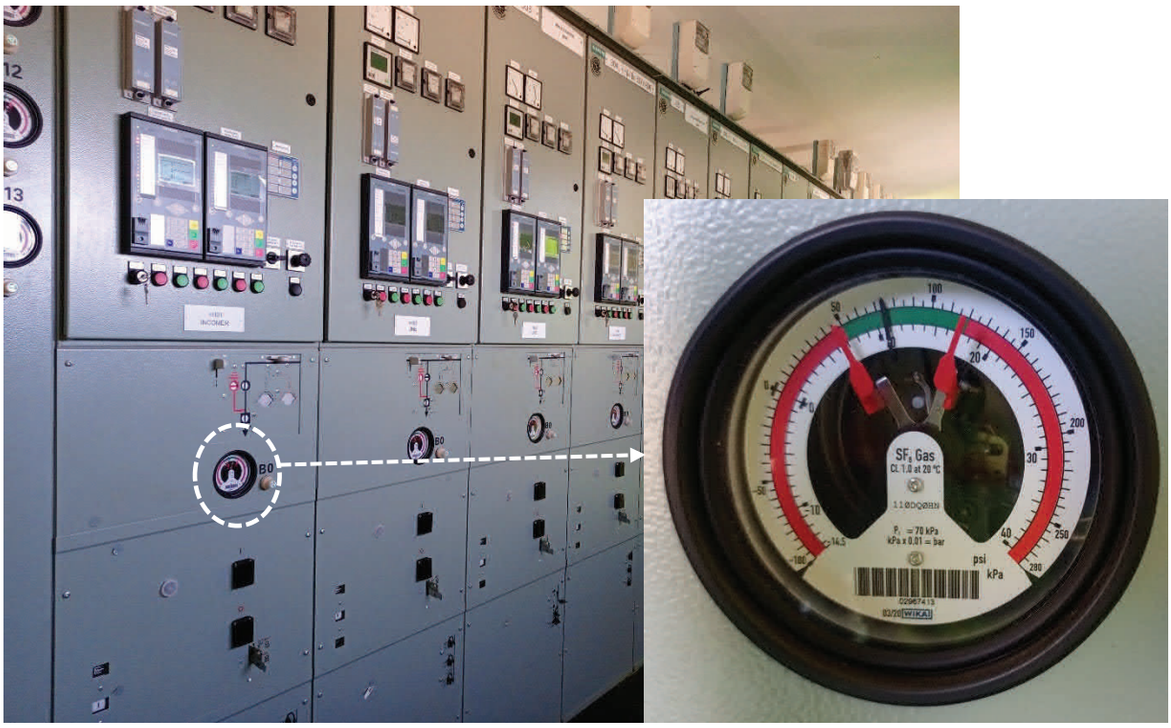


Figure 9-8: SF_6 gas circuit breakers at Tan Shan switching station in Mbale District (photo by ERA).

Overall, the grid emission factor for the national power grid of Uganda for all renewable power generation project activities have earlier been reported as 0.614. There are, however, different figures reported in different sources and updated information is required.

9.6 Climate Change Implications for the Electricity Supply Industry

Given that Uganda's Electricity Supply Industry is heavily reliant on hydropower, the sector is very vulnerable to climate change from worsening droughts, more frequent floods may damage hydropower infrastructure as experienced during dramatically high flows at hydropower plants on the Mubuku, Nyamwamba, Nyamagasani, and Lubilia Rivers in May 2020 and partly in 2023, which also necessitated costly reconstruction works (see Figure 9-9). Transmission and distribution networks may also be prone to damage. On the other hand, an increase in precipitation without more extreme weather events may result in a slight increase in hydropower generation.

In areas where the river flow does not cause damage, the extreme rainfall may trigger landslides and such incidents have affected the waterways of several hydropower projects. For instance, the Mubuku 1 hydropower plant's water intake was practically destroyed by torrential rains that fell on 7 and 10 of May 2020 and culminated in the flash flows of rivers Mubuku and Ruboni. Subsequent continuous torrential rains that fell on 31 August 2020, culminated in overflows of various surface and underground streams as well as massive run-offs over the degraded cover on the hill slopes above the flume, resulting in multiple landslides on both sides of the flume that left its total length of 105m destroyed and washed away and its other parts filled with tons of sediment material transported and deposited (see Figure 9-10).



Figure 9-9: Severe flood damage in May 2020 with flooding of the powerhouse and generation units (upper photo) and the switchyard (lower photo) at Nyamwamba HPP, Kasese District (photos by Serengeti Energy Limited).



Figure 9-10: Broken flume structure and buried parts for Mubuku 1 HPP in August 2020 (photo by ERA).

Uganda is experiencing changes in precipitation patterns due to climate change combined with changes in catchment characteristics due to land conversion, and these factors appear to increase the frequency and intensity of both droughts and floods. Droughts result in water scarcity and reduced hydropower generation, particularly in Uganda where projects generally do not have storage beyond Lake Victoria. Some of the hydropower projects must stop operations during low flow or drought conditions.

A reduction in water availability and river flow threatens potential energy generation for Uganda. Uganda particularly suffered in 2004/2005, when production of hydroelectricity declined substantially due to drought, throwing the country into a power crisis that undermined investment and slowed the country's economic growth (MWE, 2015).

The shortfalls in hydropower generation were partly filled by installing more expensive and polluting fossil fuel generation capacity.

Climate change can also affect energy demand. For example, more extreme high temperatures result in more demand for cooling among those who can afford. Climate change can also affect electric service reliability. Table 9-2 presents key climate hazards and possible impacts on power systems.

Table 9-2: Key climatic hazards and possible impacts to power systems (modified from ADB, 2012).

Climate hazard	Key impacts	Impacted segment
Increased air and water temperatures	· Lower generation efficiency in thermal power · Decreased solar PV efficiency	Generation
	· Reduced carrying capacity of lines and transformers · Increased losses in lines and transformers	Transmission and Distribution
	· Increased peak demand and total energy demand for cooling	Demand-End Use
Increase in precipitation	· Increased hydropower generation (if precipitation when otherwise dry) · Increased co-generation (if biomass production increases)	Generation
	· Damaged power lines · Flooding of underground infrastructure · Damaged towers due to erosion	Transmission and Distribution
Decrease in precipitation	· Decreased hydropower generation · Decreased availability of biomass for co-generation	Generation
More frequent/severe extreme events (floods, drought, high winds, etc.)	· Damaged infrastructure (direct impacts and indirect due to flooding, erosion, landslides, etc) · Disrupted electricity supply chains	Generation Delivery-Transmission and Distribution

Electricity generation in Uganda is particularly vulnerable to climate change effects that adversely affect hydropower. Flooding may cause damage and downtime for hydropower stations, drought will reduce generation, and changes in precipitation patterns may limit water volumes available for hydropower generation (e.g., more rainfall in

periods with already high rainfall when additional rainwater will not increase generation).

Solar PV generation can be slightly reduced due to increased temperature that reduces the solar PV cells' efficiency. However, no substantial effects are expected in Uganda even if solar PV generation is scaled up dramatically towards the large potential this source has.

Biomass co-generation may be affected more if sugar cane or other biomass production is adversely affected by climate change, or if food security imperatives mean land is converted from sugar cane to food crops.

Transmission and distribution infrastructure can be affected by climate change due to higher temperatures causing higher demand, and reduced capacity. Delivery systems physically consist of various types of power lines that transport energy, transformers which convert the power to different voltage levels, quality devices for efficiency and reliability, and protection devices that interrupt power flows during hazardous conditions. Climate change (e.g., higher temperature) can cause failures from physical hardware damage or create operational conditions that exceed hardware tolerances. If too many components are offline or the capacity of the system is significantly reduced, then power may not be available when it is needed causing cascading failures and blackouts.

9.7 Responses

The completely dominant role played by renewable energy in the electricity generation mix in Uganda over the past decade means that mitigation can be considered an existing key feature and response of the sector when it comes to climate change and greenhouse gas emissions.

The heavy reliance on hydropower, however, is a risk to electricity security, particularly in an increasingly climate-unstable future.

Adaptation and increased resilience are therefore critical, and several responses have been implemented during the past decade:

- Development of more than 20 large, medium and small hydropower projects covering different parts of the country and subject to varying climatic and catchment characteristics.
- Development of the first grid-connected solar PV projects.
- Increased co-generation capacity based on domestic biomass resources (bagasse).
- Strengthening of the transmission and distribution networks.
- Maintenance of fossil fuel generation capacity as back-up rather than base load.
- Energy efficiency measures including LED lighting and more energy efficient appliances.
- Measures to control and remove the invasive alien water hyacinth in Lake Victoria, including at the intake of Nalubaale and Kiira power stations in Jinja to minimise interference with power generation along the Victoria Nile cascade.
- ERA implements a differentiated electricity tariff system that supports a highly subsidised "cooking tariff", which is intended to incentivise the transition away from solid biomass to clean electricity.

9.8 Recommendations

9.8.1 Climate Change Mitigation

Mitigation of climate change should continue by further developing and diversifying renewable sources of electricity generation to ensure the electricity generation continues to be dominated by renewable sources. This means continued development of the proven technologies in-country such as hydropower, solar PV, and biomass where a wealth of experience now exists. Additional renewable or low-carbon technologies should also be developed and tested.

As electricity generation currently represents only a small part of the overall energy mix, there is great mitigation potential through avoiding and minimising reliance on fossil fuels in the upcoming, substantial

increase in electricity generation. Uganda's Energy Transition Plan (IEA, 2023) estimates a massive increase in electricity generation from the current 5 TWh to 200 TWh in 2050. Ensuring a low-carbon growth in electricity generation is critical for climate change mitigation.

The Energy Transition Plan assumes transitioning away from the current reliance of solid biomass for cooking (e.g., fuelwood and charcoal) to increased use of electricity. This will also be an important mitigation strategy as this will contribute to the reduced land use conversion and deforestation in Uganda.

9.8.2 Climate Change Adaptation

Even if climate change predictions are uncertain in terms of impacts on precipitation (and climate change may increase precipitation that is the resource base for hydropower), the current reliance on hydropower (> 90% of generated grid-electricity) is simply a too large risk and therefore adaptation and increase resilience are essential. Recommended strategies and measures include:

- Diversification of renewable and low-carbon sources for electricity generation.
- Introduction of storage (e.g., battery systems).
- Careful site selection for electricity installations to avoid and minimise risks of flooding, drought, and other extreme weather events.
- More climate-resilient infrastructure, including incorporate climate predictions with safety margins in infrastructure design and climate-proofing of existing infrastructure where possible.
- Increased energy efficiency measures, including demand side management to optimise electricity use and minimise unnecessary consumption.
- Continued effects to reduce losses in the transmission and distribution networks.

The Energy Transition Plan assumes that hydropower continues to expand the installed capacity, but other sources are assumed to grow much

more. The Plan assumes solar will be the dominant source by 2050 but geothermal, bioenergy, wind and hydro all play important roles in the generation mix. The Government plans to pursue nuclear power and in one of the scenarios of the Plan, nuclear is the second largest generation technology after solar.

A potential energy storage solution that can supplement battery energy storage systems is to establish additional hydropower reservoirs of substantial volume to store energy in the form of water available for later hydroelectricity generation. This may increase resilience and be an adaptation strategy, but inundation from reservoirs comes with several environmental and social impacts that require careful consideration. The potential role of additional reservoirs is not discussed in the Energy Transition Plan (IEA, 2023).

Improved catchment management and protection of the water sources areas that provide water to hydropower projects will represent increased resilience and a form of adaptation. The measures to manage catchments, however, are largely outside the Electricity Supply Industry and typically are concerned with land use, agriculture, water resources management, and non-Electricity Supply Industry stakeholders.

Considering the national black-out in 2020 caused by islands of floating water hyacinths (an aquatic weed and invasive alien species) and papyrus blocking the intake at Nalubaale hydropower station in Jinja, ensuring improved capacity to stop and remove aquatic weeds and debris at Nalubaale and Kiira hydropower stations in Jinja will strengthen resilience. The national black-out was experienced due to large volumes of hyacinths and papyrus clogging the Nalubaale water intake.

Research and monitoring of changing climatic conditions (precipitation patterns, river flows, temperature, extreme events, etc.) can enable better understanding and inform adaptation and renewable energy priorities as climate change plays out in the coming years. This may involve development of early warning systems to better manage available electricity sources and load.

9.9 References

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ANNEXES



Kikagati Hydropower Plant and switchyard, Isingiro District (photo by GET FiT Uganda).

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ANNEXES



Kikagati Hydropower Plant and switchyard, Isingiro District (photo by GET FiT Uganda).

Annex 1

Institutions and Organisations Participating at the Stakeholders' Workshop

The institutions and organisations listed below participated in the Stakeholders' Workshop on 7 March 2024 to discuss a draft version of the Electricity Supply Industry State of the Environment Report (ESISOER) at ERA Offices, Kampala. In addition to the discussions and comments provided at this workshop, several of the stakeholders also provided written comments to the draft ESISOER.

- Bujagali Energy Limited (BEL)
- Electricity Regulatory Authority (ERA)
- Frontier Energy
- Kalangala Infrastructure Services Ltd. (KIS)
- Makerere University
- Ministry of Energy and Mineral Development (MEMD)
- Ministry of Gender, Labour and Social Development (MGLSD)
- Ministry of Water and Environment (incl. Directorate of Water Resources Management, DWRM, and Climate Change Department, CCD)
- National Environment Management Authority (NEMA)
- National Forest Authority (NFA)
- Norwegian Water Resources and Energy Directorate (NVE)
- Uganda Bureau of Statistics (UBOS)
- Uganda Electricity Distribution Company Limited (UEDCL)
- Uganda Electricity Generation Company Limited (UEGCL)
- Uganda Electricity Transmission Company Limited (UETCL)
- Uganda National Meteorological Authority (UNMA)
- Uganda Wildlife Authority (UWA)
- Umeme Limited
- West Nile Rural Electrification Company (WENRECo)

Annex 2

Sources of the Main Datasets used in the GIS Analyses

Dataset	Source
Topography	https://earthexplorer.usgs.gov/
Administrative boundaries (updated as per 2021)	Uganda Bureau of Statistics (UBOS)
Roads	Uganda National Road Authority, Ministry of Works and Transport (MoWT)
Rivers, wetlands and water bodies (wetlands updated as per 2022)	Ministry of Water and Environment (MWE)
Land use (for 1990, 2015, 2022)	National Forest Authority (NFA)
Protected areas	National Forest Authority (NFA)
Power generation sites/projects	Ministry of Energy and Mineral Development (MEMD)
Transmission lines (high voltage)	Uganda Electricity Transmission Company Limited (UETCL)
Distribution lines (medium and low voltage)	Umeme Limited, Uganda Electricity Distribution Company Limited (UEDCL)
Solar Irradiation and wind intensity	https://cds.climate.copernicus.eu/
Key biodiversity areas	https://www.keybiodiversityareas.org/

The GIS analyses were undertaken by a team from Geotropic Consults Ltd. consisting of Henry Massa Makuma, Bernard Barasa, Emmanuel Ojambo, and Diana Mercy Ayikoru.

Annex 3

Supplementary Data on Electricity Supply Industry Projects

Operational Hydropower Projects

	Project	Commissioned*	Capacity (MW)	On-/off-grid
Large	Bujagali	2011	250.0	On-grid
	Isimba	2019	183.0	On-grid
	Karuma**	2023	400.0	On-grid
	Kiira	2003	200.0	On-grid
	Nalubaale	1954	180.0	On-grid
Medium	Achwa 1	2021	42.0	On-grid
	Achwa 2	2019	41.0	On-grid
Small	Bukinda	2020	6.5	On-grid
	Ishasha	2013	6.6	On-grid
	Kabalega	2013	9.0	On-grid
	Kakaka	2021	4.6	On-grid
	Kikagati	2022	14.0	On-grid
	Kyambura	2019	7.6	On-grid
	Lubilia	2018	5.4	On-grid
	Mahoma	2018	2.7	On-grid
	Mpanga	2010	18.0	On-grid
	Mubuku 1	1950s	5.0	On-grid
	Mubuku 2	2010	13.0	On-grid
	Mubuku 3	2003	9.9	On-grid
	Muyembe	2023	6.9	On-grid
	Muvumbe	2017	6.5	On-grid
	Ndugutu	2019	5.9	On-grid
Small	Nkusi	2018	9.6	On-grid
	Nyagak 1***	2014	3.5	On-grid

	Project	Commissioned*	Capacity (MW)	On-/off-grid
	Nyamwamba 1	2018	9.2	On-grid
	Nyamwamba 2	2022	7.8	On-grid
	Nyamagasani 1	2021	15.0	On-grid
	Nyamagasani 2	2021	6.0	On-grid
	Rwimi	2018	5.5	On-grid
	Sindila	2019	5.2	On-grid
	Siti 1	2017	5.0	On-grid
	Siti 2	2019	16.5	On-grid
	Waki	2018	4.8	On-grid
Mini	Kisiizi Hospital	2017	0.44	Off-grid
	Kuluva Hospital	2023	0.12	Off-grid
Micro	Bwindi	2018	0.06	Off-grid

* Capacity: Not all projects had their full capacity installed or commissioned at the stated year of commissioning.

** Karuma: An additional 200 MW to be commissioned after 2023, bringing the total installed capacity to 600 MW.

*** Nyagak 1: Originally an off-grid project. Later connected to the national grid.

Hydropower Projects Under Construction or Licensed to Start Construction

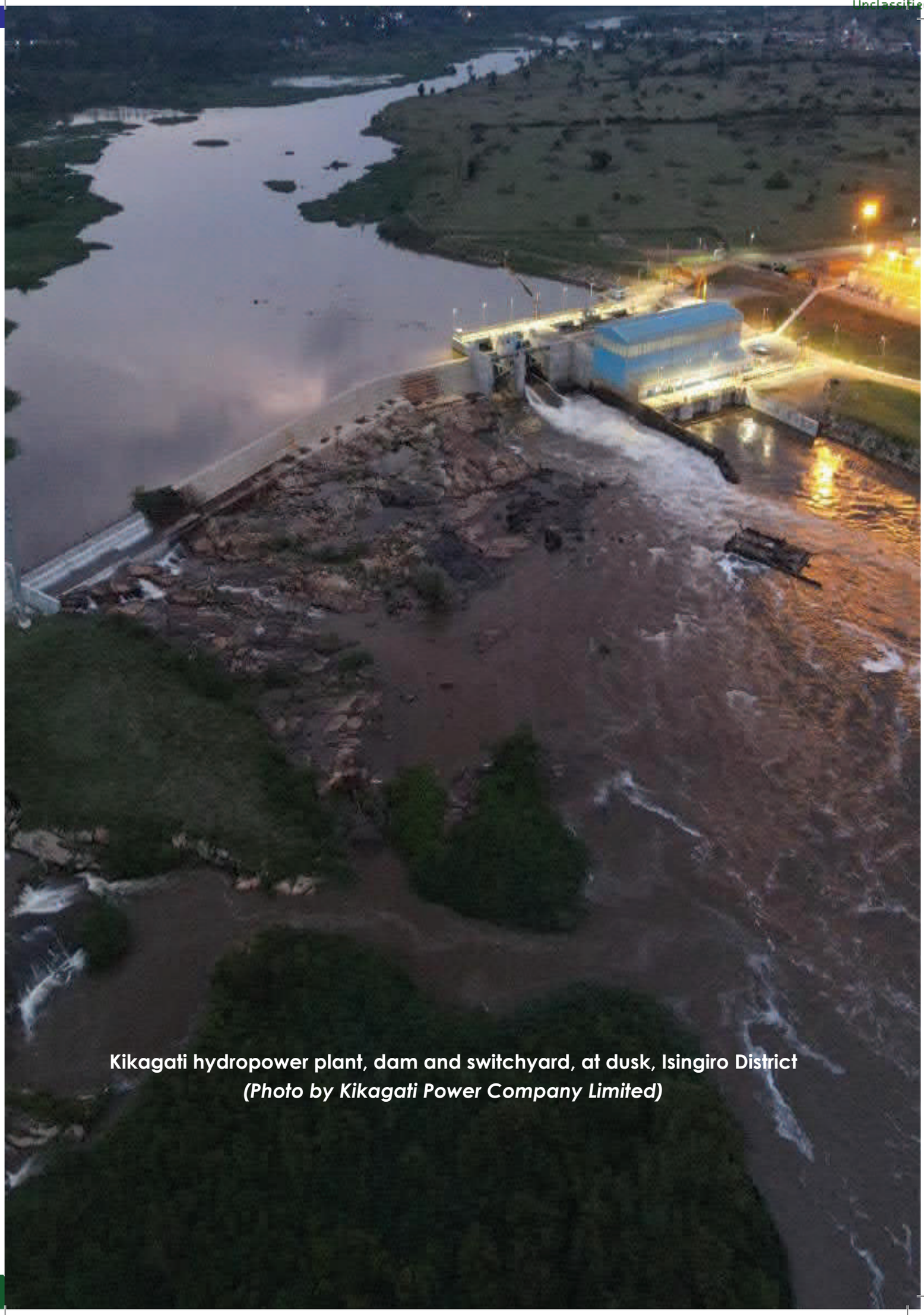
	Project	Capacity (MW)	On-/off-grid
Small	Mitaano	13.6	On-grid
	Simu	9.5	On-grid
	Sironko	7.1	On-grid
	Nyamabuye	7.0	On-grid
	Sisi	7.0	On-grid
	Nyagak 3	6.6	On-grid
	Kabeywa 1	6.5	On-grid
	Kiraboha	4.8	On-grid
	Kigwabya	4.2	On-grid
	Lirima	3.9	On-grid
	Mukoki	3.4	On-grid
	Hoimo	3.3	On-grid
	Atari 1	3.25	On-grid
	Nyabuhuka-Mujunju	3.2	On-grid
	Kabeywa 2	2.0	On-grid
Mini	Nyahuka	0.69	On-grid
	Nsongya	0.68	On-grid
	Nchwera	0.46	On-grid
	Warugo	0.46	On-grid
	Kabasanja	0.40	On-grid
	Tokwe	0.33	On-grid
	Katooke	0.31	On-grid
	Igassa	0.28	On-grid

Hydropower Projects Undergoing Feasibility Studies

	Project	Indicated capacity (MW)	On-/off-grid
Large	Ayago	840	On-grid
	Kiba	400	On-grid
	Oriang	392	On-grid
Med.	Muzizi	44.8	On-grid
Small	Lower Achwa	17.4	On-grid
	Ngenge	13.8	On-grid
	Nshongi	11.0	On-grid
	Nyakinengo	8.6	On-grid
	Mpanga 2	8.0	On-grid
	Nengo Bridge	7.5	On-grid
	Buwangani	7.0	On-grid
	Lwakhakaha	6.7	On-grid
	Cheptui	5.85	On-grid
	Keere	5.7	On-grid
	Okollo	5.0	On-grid
	Rwimi 2	5.0	On-grid
	Kiraboha	5.0	On-grid
	Kibaale	4.7	On-grid
	Nyamwamba 3	4.5	On-grid
	Buhindagi	4.3	On-grid
	Latoro	4.2	On-grid
	Rubabo	3.7	On-grid
	Mihunga	2.0	On-grid
	Kanyabaha	1.8	On-grid
	Kanyampara	1.6	On-grid
	Maziba	1.2	On-grid
Mini	Rwembya	0.4	Off-grid

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Kikagati hydropower plant, dam and switchyard, at dusk, Isingiro District
(Photo by Kikagati Power Company Limited)

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