UNIVERSITY OF RWANDA

COLLEGE OF SCIENCE AND TECHNOLOGY

AFRICAN CENTERS OF EXCELLENCE IN ENERGY FOR SUSTAINAIBLE DEVELOPMENT

MSC IN ENERGY ECONOMICS

RESEARCH TOPIC: THE ECONOMIC EFFECTS OF PHASING OUT THE USAGE OF PEAT IN RWANDA

NAMES: NZABAHIMANA Flavien **Reg. NUMBER:216266769**

SUPERVISOR: Dr. HAKIZIMANA Jean de Dieu

DECLARATION

I, **NZABAHIMANA Flavien,** hereby declare that this Dissertation entitled ‘’ The economics effects of phasing out the usage of peat energy in Rwanda ‘’ is my original work and has never been presented elsewhere for any other academic qualification at any university or institution of higher learning. All sources of materials used for this Dissertation was fully acknowledged.

DATE:15/10/ 2025

NZABAHIMANA Flavien

Signature

Dr. HAKIZIMANA Jean de Dieu

Signature…………………………………………………

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ABSTRACT

Peat has been a crucial component of Rwanda's energy sector, primarily used for electricity generation and industrial processes. However, due to its environmental impact and Rwanda's commitment to sustainable energy transition, its need to be phased out. This shift aligns with global efforts to reduce carbon emissions and promote renewable energy. The transition, however, presents economic, environmental, and social challenges that require in-depth analysis. This study the economic effects of phasing out the use of peat in Rwanda. It evaluates the economic consequences, environmental benefits, energy security considerations.

This study applies LEAP energy and emission modeling to analyze different scenarios of phasing out and its economic effects. The results shows that more than 715.6 GWh of peat energy lost as results of transition, peat energy result to 13.4 MT of greenhouse gas emission, so phasing out would reduce the emission that contribute to environmental sustainability, it poses short-term economic challenges. Industries dependent on peat, energy such as cement manufacturing and tea processing, may experience increased production costs. Additionally, the transition had an effect on employment in peat extraction and related industries, necessitating government intervention in workforce reskilling and job creation in renewable energy sectors.

Rwanda must implement strategic policies, including financial incentives for industries shifting to renewable energy, investment in research and development of alternative energy sources, and regional cooperation in energy trade.

LIST OF ACRONYMS

BAU – Business As Usual

CO_2 – Carbon Dioxide

ESSP – Energy Sector Strategic Plan

GGCRS – Green Growth and Climate Resilient Strategy

GHEs – Greenhouse Gas Emissions

GWh – Gigawatt Hour

IPCC – Intergovernmental Panel on Climate Change

LEAP – Long-range Energy Alternatives Planning

MININFRA – Ministry of Infrastructure

MINECOFIN – Ministry of Finance and Economic Planning

MW – Megawatt

NDC – Nationally Determined Contributions

NGOs – Non-Governmental Organizations

NISR – National Institute of Statistics of Rwanda

NO_2 – Nitrogen Dioxide

PM2.5 – Particulate Matter (fine particles with a diameter of 2.5 micrometers or less)

PV – Photovoltaic

REG – Rwanda Energy Group

REMA – Rwanda Environment Management Authority

RURA – Rwanda Utilities Regulatory Authority

RWF – Rwandan Franc

TJ – Terajoule

UNDP – United Nations Development Program

WHO – World Health Organization

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CHAPTER 1. INTRODUCTION

1.1. GENERAL INTRODUCTION

Energy plays a pivotal role in the economy and development strategies of Rwanda. It underpins various sectors, such as housing and urban development, manufacturing, Agri- business, mining, tourism, and information technology services. Therefore, an effective and efficient energy sector is essential for the country to realize its national objectives. By the end of November 2024, 81.4% of Rwandan houses were cumulatively connected, with 56.5% of them using the national grid and 24.9% using off-grid solutions, primarily solar (REG,2018).

According to The Energy Sector Strategic Plan (ESSP) 2024–2029, The ESSP intends to address important problems over the next five years, such as restricted access to electricity, ineffective energy infrastructure, and dependence on conventional cooking techniques, while establishing the groundwork for the energy future of Rwanda.

The ESSP outlines six strategic priorities for 2024–2029 that are in line with Rwanda's international obligations under the Nationally Determined Contributions (NDC) and the Green Growth and Climate Resilient Strategy (GGCRS). These include expanding the national grid, promoting clean cooking technology, developing power producing projects, improving street lighting along major highways, and scaling up access to electricity both on and off the grid. As outlined in Vision 2050, these initiatives are essential to Rwanda's objective of promoting sustainable economic growth and making the transition to cleaner, more dependable energy systems, all makes the energy sector priority for sustainable development **(**MINECOFIN,2024**)**

1.2. BACKGROUND OF THE STUDY

Peat, a substance formed from partially decayed plant material in waterlogged conditions, has been utilized for centuries as a source of fuel and as a growing medium in horticulture. Despite its historical significance and widespread use, there has been growing concern over the environmental impact of peat extraction and use.

This concern has led to policies aimed at phasing out peat, primarily due to its significant role in carbon sequestration, the preservation of biodiversity, and the maintenance of hydrological systems peat are extracted in so called Peatlands, covering approximately 3% of the Earth's land surface, are among the most efficient carbon sinks, storing about one-third of global soil carbon. The extraction of peat, however, reverses this process, releasing vast amounts of stored carbon into the atmosphere, thus contributing to greenhouse gas emissions and climate change (Joosten & Clarke, 2002). When peat is drained and extracted, the organic material oxidizes, releasing carbon dioxide (CO_2), which is a major greenhouse gas. For instance, drained peatlands emit approximately 5% of all anthropogenic CO_2 emissions annually (Parish et al., 2008). The contribution of peat extraction to climate change has led to increasing calls for the protection and restoration of peatlands as a critical component of climate mitigation strategies.

Peatlands are unique ecosystems that support a diverse range of flora and fauna, including many species that are rare, threatened, or endemic. The degradation of these ecosystems through peat extraction leads to habitat loss and a decline in biodiversity (Bonn et al., 2016). For example, the draining of peatlands for extraction or agricultural conversion has resulted in the loss of habitat for species such as the curlew (Numenius arquata), which relies on the wet conditions of peatlands for breeding (Andersen et al., 2017). The importance of peatlands for biodiversity conservation has been recognized globally, prompting efforts to phase out peat extraction and implement conservation measures.

Peatlands play a critical role in regulating water flow and maintaining water quality. They act as natural water reservoirs, storing water during wet periods and releasing it during dry periods, thereby reducing the risk of flooding and maintaining streamflow (Joosten & Clarke, 2002). The extraction of peat disrupts these hydrological functions, leading to altered water regimes, increased flood risk, and deteriorated water quality (Parish et al., 2008). The loss of these functions further emphasizes the need for phasing out peat extraction and restoring degraded peatlands.

The growing awareness of the environmental impacts of peat extraction has led to the development of policies aimed at reducing or phasing out peat use. At the global level, initiatives such as the Ramsar Convention on Wetlands have highlighted the importance of peatlands and the need to conserve and sustainably manage these ecosystems (Bonn et al., 2016). Additionally, the European Union has implemented the Habitats Directive, which includes specific provisions for the protection of peatlands and other important habitats (European Commission, 2020).

Several countries have introduced national policies to phase out peat extraction, particularly for use as a fuel. Ireland, for example, has traditionally relied on peat as a significant energy source but has initiated a gradual phase-out, with plans to cease peat-fired electricity generation by 2028 (Andersen et al., 2017). Similarly, Finland has reduced its reliance on peat for energy, with a focus on transitioning to renewable energy sources such as wind, solar, and biomass. These national initiatives are often integrated into broader climate action plans aimed at reducing greenhouse gas emissions and promoting sustainable land use practices.

One of the key strategies in phasing out peat is the promotion of alternative renewable energy sources. Countries that have historically depended on peat for energy are increasingly investing in wind, solar, and biomass as sustainable alternatives (Andersen et al., 2017). These renewable sources not only provide a more sustainable energy option but also contribute to reducing greenhouse gas emissions and mitigating climate change.

In the horticulture industry, peat has been widely used as a growing medium due to its excellent water retention and nutrient properties. However, the environmental impact of peat extraction has led to the exploration of sustainable alternatives. Materials such as coir (coconut fiber), composted bark, wood fiber, and perlite are being increasingly used as substitutes for peat in horticulture (Bonn et al., 2016). These alternatives not only reduce the demand for peat but also promote sustainable horticulture practices that are less damaging to the environment.

Phasing out peat presents significant economic and social challenges, particularly in regions where peat extraction is a major industry. In countries like Ireland and Finland, the peat industry has historically provided employment and economic benefits to rural communities (Andersen et al., 2017).

The transition away from peat requires the development of alternative livelihoods and energy sources, which necessitates support from governments, industry, and stakeholders. This transition must be managed carefully to minimize social and economic disruptions.

The restoration of degraded peatlands is a critical component of the peat phase-out process. Restoration efforts aim to reestablish the natural hydrological conditions of peatlands, promote the growth of peat-forming vegetation, and restore the carbon sequestration capacity of these ecosystems (Joosten & Clarke, 2002). Successful restoration not only helps to mitigate climate change but also supports biodiversity conservation and the recovery of ecosystem services. However, restoration is a complex and long-term process that requires significant investment and expertise.

The peat deposit in Rwanda is distributed on over 50,000 ha, and peat in the Akanyaru was formed early around 20,000 years before the last end of glaciation period .(Kigali, 2011). Studies indicate that Rwanda has a deposit of 155 million tons of dry peat which can generate energy requirements for over 30 years (Mugerwa et al., 2020). The energy sector's dependence on peat, a significant source of greenhouse gas emissions, poses environmental and sustainability challenges. This research proposal aims to explore various scenarios for phasing out peat in the energy sector. The study will evaluate the feasibility, economic impact, and environmental benefits of transitioning from peat to alternative energy sources. Through a comprehensive analysis, the proposal seeks to identify the most viable strategies for reducing the sector's carbon footprint while ensuring energy security and economic stability.

1.3. RESEARCH PROBLEM

Peat, a fossil fuel found in waterlogged areas, is currently one of the significant contributors to Rwanda's energy generation mix. While it offers short-term energy security and economic value, peat is a carbon-intensive resource and its continued exploitation raises critical environmental concerns. As Rwanda strives to meet its climate targets under the Paris Agreement and its own Green Growth and Climate Resilience Strategy, the continued use of peat presents a contradiction to its long-term sustainability objectives (Government of Rwanda, 2011).

Rwanda has made notable progress in expanding access to electricity and improving energy security. According to the Rwanda Energy Group (REG), as of 2024, the national electrification rate stood at approximately 81%, with plans to achieve universal access by 2030. Peat has played a role in this achievement, particularly through the development of peat-fired power plants such as Gishoma and Nyabarongo (REG, 2023). However, the environmental implications of peat use including greenhouse gas emissions, land degradation, and disruption of wetland ecosystems cannot be overlooked. Peatlands are vital carbon sinks, and their disturbance accelerates carbon release, undermining national and global climate goals (Joosten & Clarke, 2002).

The central problem is that while peat energy provides short-term benefits, it poses long-term environmental and economic risks. The cost of environmental degradation, loss of biodiversity, and emissions may outweigh the perceived economic benefits of peat extraction. Moreover, Rwanda's vulnerability to climate change makes the transition to cleaner energy sources an urgent necessity (MINIRENA, 2016). This study seeks to examine the economic effects of phasing out peat energy in Rwanda's energy system.

1.4. RESEARCH OBJECTIVES

1.4.1 General objectives

The overall objective of this study was to study the economic effects of phasing out the use of peat in Rwanda.

1.4.2. The specific objectives

The specific objectives of this research are:

I. To examine the contribution of peat in Rwanda
II. To evaluate the contribution of peat energy to emissions
III. To assess the contribution of peat energy to GDP per capita.

1.5. RESEARCH QUESTION

A. What are contributions of peat in Rwanda energy sector?

B. What the contribution of peat energy to emission?

C. What is the contribution of peat energy to employment?

1.6. SCOPE OF THE STUDY

This study is limited to economic growth, emissions and peat energy

1.7. ORGANIZATION OF THE STUDY

This thesis has five chapters, for which chapter one cover. Introduction of the study, background of the peat in general and particularly in Rwanda, research problem, research question and research objective and scope of the study. Chapter two cover the literature review, description of key terms related to my topic (theoretical review and empirical review of the topic). Chapter 3. Discussed the methodology and the research process such as data collection and data analysis. Chapter 4. Discussed the findings and results emissions from peat energy and socio-economic impacts of peat phasing out. Chapter 5 includes the summary of the results, conclusion and policy recommendation

CHAPTER 2. LITERATURE REVIEW

Literature review is to go through of what other scholars and researchers has said that are mainly related to the chosen topic where I can draw research gaps. In this chapter I will discuss theoretical review, empirical review and conceptual framework

2.1. INTRODUCTION

Previous research highlights the environmental drawbacks of peat extraction and combustion. Studies indicate that peatlands are critical carbon sinks; their degradation leads to substantial CO_2 emissions(Rieley, 2010.) Furthermore, alternative energy technologies, such as wind, solar, and Hydro, have been identified as potential replacements for peat (The State of the World's Peatlands, 2022).

Environmental Impact of Peat: Peatlands cover only 3% of the earth's land surface but store approximately 30% of the world's soil carbon. The destruction of these ecosystems for fuel has significant environmental repercussions. Alternative Energy Sources: Renewable energy technologies have advanced considerably, offering viable alternatives to peat. Wind and solar power have become more cost-effective and widely adopted. Economic and Social Implications: Transitioning from peat to alternative energy sources involves economic restructuring and social adjustments, particularly in regions heavily reliant on peat for employment and energy(Kigali, 2011)

Peatlands are wetlands characterized by the aggregation of somewhat rotted natural matter due to waterlogged conditions that moderate deterioration. These biological systems have created over thousands of a long time, sequestering huge sums of carbon.

Intaglio peatlands work as carbon sinks, putting away roughly 600 gigatons (Gt) of carbon all inclusive, which is more than the combined carbon put away in all earthbound vegetation (Page et al., 2011). In any case, when peatlands are depleted or burned, they ended up noteworthy carbon sources, discharging put away carbon within the frame of carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O) (Hoojier et al., 2010). Worldwide Peatland Dispersion and Outflows Peatlands are found on each landmass but Antarctica, with the biggest saves in Canada, Russia, Indonesia, and the Joined together States.

The change of these scenes for farming, ranger service, and vitality generation has driven to broad carbon emanations. Indonesia alone, through deforestation and peatland debasement, contributes to a noteworthy parcel of worldwide peat outflows, especially from peatland fires

(Miettinen et al., 2017). All inclusive, peat corruption is dependable for roughly 5% of yearly anthropogenic CO2 emanations, assessed at around 1.9 gigatons per year (Leifeld & Menichetti, 2018).

2.1.1. Peat production for energy use

Peatland fires, frequently started to clear arrive for palm oil and pulpwood ranches, worsen these emanations. Amid the 2015 El induced fires in Southeast Asia, peatland burning come about in outflows surpassing 1.5 Gt CO2e, comparable to Japan yearly fossil fuel outflows (Huijnen et al., 2016).

Peat Extraction for Vitality and Its Suggestions Peat has generally been utilized as vitality source, particularly in Finland, Sweden, and Russia, where it is burned for power and warm era. Whereas considered a slow-renewable asset, its combustion discharges more CO2 per unit of vitality compared to coal (Area et al., 2008). The European Union has progressively recognized peat as a high-emission fuel source, driving to approach shifts toward its phase-out in favor of renewable choices (Bonn et al., 2016).Climate and Natural Results Peatland corruption comes about in long-term natural results past carbon outflows. The misfortune of peatland environments diminishes biodiversity, modifies hydrological cycles, and increments surge dangers. The discharge of CH4, a strong nursery gas, contributes essentially to global warming, as methane includes a worldwide warming potential 28 times higher than CO2 over a 100-year period (IPCC, 2021).

Also, nitrogen-rich peat soils can radiate N2O, which incorporates a warming potential about 300 times that of CO2 (Crill et al., 2000). Procedures for Peat Outflow Diminishment Endeavors to relieve peat emanations center on peatland preservation, rewetting, and feasible arrive utilize administration.Rewetting depleted peatlands through water table reclamation can essentially decrease CO2 emanations whereas advancing biodiversity (Griscom et al., 2017).Universal activities such as the Worldwide Peatlands Activity point to upgrade peatland security and rebuilding through arrangement systems and budgetary motivating forces (UNEP, 2019).

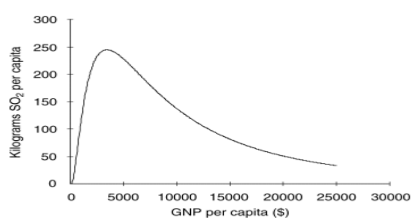
A few nations have moreover presented controls to control peatland corruption. Indonesia, for occurrence, has actualized a ban onunused peatland improvement and started peatland reclamation ventures covering millions of hectares (Miettinen et al., 2017). Essentially, the European Union has coordinates peatland conservation into its climate approaches, incentivizing wetland rebuilding as portion of its carbon sequestration methodology (Bonn et al., 2016).

2.2. THEORITICAL REVIEW

2.2.1. SUSTAINABILITY THEORY

The Kuznets Curve of sustainability

The Kuznets Curve, an economic hypothesis proposed by Simon Kuznets in the 1950s, suggests an inverted-U relationship between economic growth and environmental degradation. Initially, as an economy grows, pollution and environmental damage increase, but after reaching a certain income threshold, further growth leads to environmental improvements due to better regulations and technological advancements.



SOURCE: Earth and planetary sciences

The Environmental Kuznets Curve (EKC) posits that pollution rises with economic growth at lower income levels, peaks at an intermediate stage, and then declines as higher incomes allow for investment in cleaner technologies and regulations. This framework has been widely used to analyze carbon emissions, deforestation, and other environmental indicators. Several empirical studies support the EKC for various pollutants, though there are exceptions. Stern (2004) argues that while the curve may hold for localized pollutants such as sulfur dioxide, its validity for global emissions like CO2 is debated.

The Alpine Convention on Soil Conservation (1998) protocol, which was signed and ratified by all parties in 2006, includes a commitment to phase out the use of peat. Nevertheless, at this point, no strategy had been developed at the EU level. Despite the development of political initiatives in the Netherlands and Ireland, Germany remains the sole member state of the European Union to have formally established goals for political reduction on the use of peat in gardening. The horticultural sector and the expanding media business view the reduction of peat as a challenge, which implies the industry's adjustment to new materials as well as the possible rise in production prices.

Consequently, in a circumstance in which horticultural materials, growth media, and peat are heavily state of the European Union to have formally established goals for political reduction on the use of peat in gardening. The horticultural sector and the expanding media business view the reduction of peat as a challenge, which implies the industry's adjustment to new materials as well as the possible rise in production prices.

2.2.2. PEAT AND ITS USE

I. Raw material in industry

The chemical processing of peat for agriculture is carried out in small- and large-scale variants. Small-scale processing includes the manufacture of humic growth regulators; humic fertilizers with microelements, in which hemic substances carry out a role of biologically active binders; and also, natural ecologically clean means for the protection of plants from diseases both at cultivation and during storage(Hirschler et al., n.d.)

Medicine and cosmetics

The chemical treatment of peat for medicine, cosmetics, balneology and veterinary medicine is based both on the structural peculiarities of the peat raw material and the biological variety of peatland vegetations. More than 50 herb varieties grow on peatlands and are part of the peat formation processes, including: Coma rum palustre, Menyanthes trifoliata, Valeriana officinalis, Ledum palustre, Oxicoccum quadrifoliate, as well as many species of the families Salicacea, Pinacea, Betulacea, Sphacea, and their biologically active substances are accumulated in peat.

II. Activated carbon.

Thermal processing in combination with chemical modification of peat makes it possible to obtain a wide variety of activated carbon with specific pore sizes including molecular-sieve properties for the purification of gas and liquid mediums. Very pure and safe varieties of activated carbon are produced for medicine, the food industry and wine-making effects could arise in the European market and/or make unlimited use of peat. There is a chance that the peat extraction will move, perhaps from German across the Baltic States. Similarly, horticulture production might be shifted from Germany to neighboring nations.

III. Energy generation

Over the period, peat has been extracted for energy generation. In Rwanda peat -to-power generation power plant has been constructed and has started generating electricity and power are connected as well as the remaining has been connected to the national grid to be used in other sector of the economy.

2.3. PEATLAND AS A KEY TO ENVIRONMENTAL PROTECTION

The Sustainability and Ethical Theory centers on the moral and ethical responsibility to preserve natural resources for future generations. This theory emphasizes that the phasing out of peat is essential to achieve sustainability, as continued use of peat is incompatible with the principles of sustainable development. It also raises ethical concerns about the exploitation of natural resources at the expense of global environmental health and future human welfare.

Peatlands are vital ecosystems that play a critical role in climate regulation, biodiversity conservation, and water management. In Rwanda, a country renowned for its stunning landscapes and rich biodiversity, peatlands are particularly significant. However, these vital ecosystems are under threat from various human activities and environmental pressures. This research will examine in details the challenges faced in conserving these areas, and proposes potential solutions to enhance peatland management and conservation.

The below picture shows the peat extraction, and explain the effects of the peatland extraction on biodiversity living in peatland areas.

2.3.1. Peatlands

Peatlands in Rwanda are essential for several reasons. Firstly, they act as carbon sinks, storing large amounts of carbon dioxide (CO_2) and thus mitigating climate change (Clarke & Rieley, 2019). Peatlands accumulate peat, a type of soil that forms from decayed plant material in waterlogged conditions, and this accumulation can store carbon for thousands of years. This makes peatlands one of the most efficient carbon storage systems on Earth.

Secondly, peatlands contribute to biodiversity conservation. They provide habitat for a range of species, including rare and endemic flora and fauna. For instance, the Rugezi Marshland, one of Rwanda's significant peatlands, is home to a variety of bird species and amphibians that

are adapted to these unique environments(Assessment on Peatlands, Biodiversity, and Climate Change, 2008).
Moreover, peatlands play a crucial role in water regulation. They act as natural water filters, improving water quality by trapping sediments and pollutants. Additionally, they help in regulating water flow, reducing the risk of floods and maintaining water levels in surrounding areas.

  s

This photo: show how peatland are destroyed in peat extraction

Source:(England Peat Action Plan, 2021)

2.3.2. RWANDA PEATLAND AND HUMANA ACTIVITY

Despite their importance, peatlands in Rwanda face numerous threats that jeopardize their health and functionality, those challenges are the main cause of more carbon release which will hamper the diversity and ecosystem hence the violation of environmental protection policies.
Agriculture is a major driver of peatland degradation in Rwanda. As the population grows and the demand for food increases, there is a push to convert peatlands into arable land. This transformation disrupts the natural hydrology of peatlands, leading to a loss of peat accumulation and increased carbon emissions.
Peatlands are often drained to facilitate logging activities. Deforestation not only contributes to the loss of habitat but also exacerbates carbon emissions, as the peat becomes more susceptible to oxidation and decomposition when exposed to air.
The expansion of infrastructure, including roads and buildings, poses a threat to peatlands. Construction activities often lead to the draining and fragmentation of these ecosystems, further compromising their ecological functions.
Climate change impacts peatlands by altering temperature and precipitation patterns. Increased temperatures can lead to higher rates of peat decomposition, while changes in precipitation can affect the water levels in peatlands, disrupting their ecological balance.

In many cases, there is a lack of awareness about the importance of peatlands among local communities and policymakers. Additionally, insufficient regulatory frameworks and enforcement mechanisms contribute to the degradation of these ecosystems.

2.3.3. PEATLAND RESTORATION

Addressing the challenges facing peatland protection in Rwanda requires a multifaceted approach that includes policy, community engagement, and scientific research. Several opportunities and solutions can be explored.

Developing and enforcing robust policies and regulations is crucial for peatland conservation. This includes creating protected areas for peatlands, regulating land use, and implementing restoration programs. The Rwandan government should prioritize peatland protection in its environmental and climate policies. Encouraging sustainable agricultural practices and land use can help reduce the pressure on peatlands.

Practices such as agroforestry, which integrates trees with crops, can minimize the impact on peatlands while supporting local livelihoods. Initiating and supporting peatland restoration projects can help rehabilitate degraded areas. Restoration efforts may involve rewetting drained peatlands, replanting native vegetation, and monitoring the recovery of these ecosystems. Educating local communities about the value of peatlands and involving them in conservation efforts can lead to more effective protection. Community-based initiatives, such as participatory management and eco-friendly livelihoods, can contribute to the preservation of peatlands. Continued research and monitoring are essential for understanding the dynamics of peatlands and assessing the effectiveness of conservation measures.

Collaborative research with academic institutions and international organizations can provide valuable insights and support informed decision-making. International cooperation and funding can play a significant role in peatland protection. Engaging with global environmental organizations and securing financial support for conservation projects can enhance efforts to safeguard peatlands in Rwanda.

2.4. CARBON EMMISION IN RWANDA

Rwanda and the IPCC agreement has committed to set up measures to reduce the Green House Emissions (GHEs), from 2015, using the Leap model and take 2015 as the baseline and they calculated and projects the emissions in BAU (Business As Usual), by using 5.3 MtCO2e in the base year to around 12.1 MtCO2e in 2030. With the domestically supported unconditional mitigation measures, 2030 emissions are forecast to instead rise to around 10.2

MtCO2e, indicate a reduction against BAU of about 16%. With both unconditional (domestic) and conditional mitigation measures, emissions were projected instead total about 7.5 MtCO2e, which show a decrease of 38% by 2030 against the same baseline (GGCRS,2023)

Figure 1:HOW PEAT POLLUATE ENVIRONMENT THROUGH EXTRACTION

Emissions between 2020 and 2030 are anticipated to come from the energy and Industries related to agriculture (Republic of Rwanda, 2020). Nonetheless, there is significant potential for low-carbon solutions to be implemented in both the energy and agricultural sectors. If Rwanda is to fulfill its pledges to mitigate climate change, while

In addition to reaching its aggressive 11% economic growth goals, it needs to implement coordinated green energy policy.

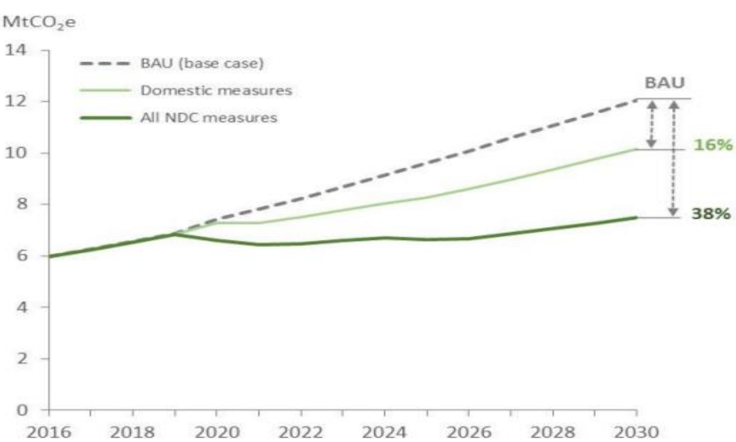


Figure 2: Mitigation against the Increase of the emission by 2030

Source: (Rwanda Carbon count report ,2020)

In commitment to reduce the emission by 2030 energy sector has planned to reduce the emission to about 1.5 million tco_2 eq.

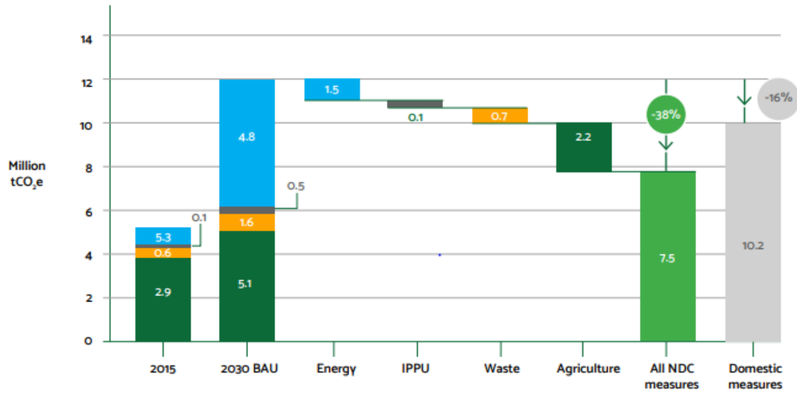


Figure 3. RWANDA COMMITMENT TO REDUCE EMISSION BY 2030

sources: (GGCRS,2023)

2.5. ENERGY SECTOR IN RWANDA

Rwanda, a landlocked country in East Africa, has historically faced significant energy challenges due to limited natural resources and infrastructural constraints. Prior to the discovery and utilization of peat as an energy source, the country relied heavily on traditional biomass, hydropower, and imported fossil fuels to meet its energy demands (MININFRA, 2012). These limitations hindered economic growth and sustainable development.

Before the introduction of alternative energy sources, Rwanda's energy mix was dominated by traditional biomass, primarily firewood and charcoal. According to the Rwanda Energy Group (2015), over 85% of the population relied on biomass for cooking and heating. The extensive use of firewood contributed to deforestation and environmental degradation, exacerbating challenges related to soil erosion and loss of biodiversity (REMA, 2011). Additionally, the inefficiency of traditional cooking methods resulted in high indoor air pollution, which posed health risks, particularly to women and children (WHO, 2014).

Despite its reliance on biomass, Rwanda made efforts to develop hydropower as an alternative energy source. By the early 2000s, hydropower accounted for approximately 50% of the country’s electricity generation (MININFRA, 2012). However, the potential of hydropower was limited by factors such as seasonal fluctuations in water levels and increasing demand for electricity. Prolonged droughts often led to power shortages, affecting industries and households alike (World Bank, 2010).

To supplement its limited domestic energy production, Rwanda imported significant amounts of petroleum products, including diesel and kerosene. These imports accounted for a substantial portion of the country's energy expenditure, making the economy vulnerable to global oil price fluctuations (NISR, 2013). The high cost of imported fuels also contributed to the expensive electricity tariffs, making access to electricity unaffordable for many Rwandans (AfDB, 2015). Moreover, the reliance on imported fossil fuels increased the country's trade imbalance, placing additional pressure on foreign exchange reserves (IMF, 2016).

Before the peat energy potential was identified, Rwanda faced substantial challenges in expanding electricity access, especially in rural areas. In the early 2000s, only about 6% of the population had access to electricity, with rural areas experiencing even lower electrification rates (EDCL, 2012). The lack of reliable electricity hindered social and economic development, affecting essential sectors such as healthcare, education, and agriculture (World Bank, 2013). Efforts to promote off-grid solutions, such as solar energy, were in their infancy and had not yet reached significant penetration levels (MININFRA, 2014).

I. HYDROPOWER

Rwanda's generally hydropower potential has been evaluated at up to 400 MW, in spite of the fact that this shifts by think about. An evaluation of the vitality segment attempted by the Africa Improvement Bank in 2013 assessed Rwanda's residential hydropower potential at 313 MW, broken down into 130 MW of residential and 183 MW of territorial hydro resources17.

II. PEAT TO CONTROL

A nitty gritty ponder and appraisal of peat lowlands in Rwanda and their potential utilize as a source of fuel for control era distributed in 2016 expressed that " from the 13,571- ha range considered, roughly 23 to 33 million dry tons of peat can be delivered from an exploitable range of 4,057 ha. This peat can create between 97 and 129 Tsw for 30 a long time, at an assessed level of between 121 and 161 MW18.

III. GEOTHERMAL VITALITY ASSETS

Rwanda's geothermal asset amount estimation needs broad ponders to be demonstrated. At this time, it should be famous as it were that, ponders have recognized Karisimbi, Kinigi, and Gisenyi.

IV. SUN BASED VITALITY.

The consider approximately sun-oriented vitality in Rwanda was conducted by the Joined together States (U.S.) National Discuss and Space as well as the College of Rwanda .It was evaluated that the month to month normal worldwide sun-based radiation changes between 4.3 and 5.2 kWh per meter squared per day. In any case, the eastern territory has the most prominent potential for producing vitality from sun-oriented assets. In 2014, in expansion to numerous households through sun powered PV establishments, Rwanda had two sun oriented PPV-based control plants, one of 250 kW and the other of 8.5 MW, associated to the national grid.

V. METHANE GAS

It was affirmed by the most recent consider that Lake Kivu has 60 to 70 cubic kilometers of methane (CH_4) from which 44.7 cubic kilometers can be extricated. There's a little yearly aggregation of 0.14 cubic kilometers per year. The sum of power that can be delivered from this methane depends on the extraction. This adequacy is right now assessed at 28%, lower than the 40 to 60% at first anticipated. In this way, the beginning figures of 700 MW of generation over 50 a long time (to be partitioned between Rwanda and the Majority rule Republic of Congo (DRC) have been changed downwards to 350 MW.

VI. BIOMASS.

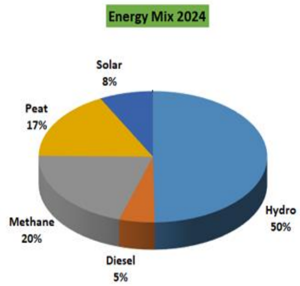
Small-scale control era utilizing buildups from horticulture (such as bagasse or rice husks) or biomass briquettes (from compacted squander buildups or charcoal clean) is doable at moo levels of capacity. In any case, due to the way of life in urban zones.

2.5.1. PEAT CONTRIBUTION TO THE ELECTRICITY ACCESS IN RWANDA

Over 30 years government of Rwanda has been committed to accelerate economic growth in all sectors of the economy energy sector included. Energy sector growth was among the priority sector to boost economic growth and development, according to the Rwanda energy group (REG), 65.7% of the households in Rwanda had been electrified that includes 47.6% of households connected to the national grid and 18.1% are connected using off-grid solutions mainly solar home systems (REG,2023). and the generation capacity was 46.33% of electricity generation in the year 2023 are from Hydro, 23.48% from Methane Gas, 13.39% from Peat, 6.79% from Thermal, 1.40% from Solar energy and 8.61% are the imports. In general, the 47.73% of electricity generated during 2023 are from renewable resources and 43.66% are from nonrenewable resources whereas the 8.61% are imported electricity

Hydropower and thermal power continue to dominate with the highest shares of the installed generation capacify of 109.662 MW equivalent for 31.03%, while shared and solar power contributes the least 3.40% and 3.41 % respectively as per the fable and graph below

Table 1:RWANDA ENERGY GENERATION MIX



Energy generation mix by 2024.(source :REG:2024 energy report)

Types	Installed Capacity	Percentage
Hydropower	109.662	31.03%
Import	46.1	13.04%
Methane Gas	29.79	8.43%
Peat Fired PP	85	24.05%
shared	12	3.40%
Solar Power	12.05	3.41%
Thermal Power	58.8	16.64%
Total	**353.402**	**100%**

Table 3:Summary of capacity by source as of June 2023

ENERGY MIX		
Types	Installed Capacity	Percentage
Technology	Generation /kWh	%
Hydropower	494,021,729.82	41.19%
Import	37,839,678.62	3.16%
Methane Gas	225,037,264.11	18.76%
Peat Fired PP	174,847,966.56	14.58%
shared	75,320,000.00	6.28%
Solar Power	17,828,430.75	1.49%
Thermal Power	**174,432,660.00**	**14.54%**
Total Generation	**1,199,327,729.86**	**100.00%**

Table 4: Summary of energy mix during FY 2022/23

Source :(REG annual report, 2022-2023)

In many countries' peat are extracted not only for energy purposes but for many reasons and use, these include for agriculture, medicine, cosmetics, gardening and horticulture. Other countries including Rwanda energy serve as the source of energy to reduce energy electricity imbalances and to accelerate the electricity access among Rwandan. Even though extraction of peat has many climate and environment effects.

Rwanda has an estimated 155 million tons of peat reserves, primarily located in the Akanyaru, Nyabarongo, and Rwabusoro wetlands (Government of Rwanda, 2018). The country has leveraged these reserves to generate electricity and fuel industrial activities. The Gishoma Peat Power Plant, commissioned in 2017, marked a significant milestone in peat-based electricity generation, contributing 15 MW to the national grid (REG, 2020). Additionally, the ongoing construction of the 80 MW peat-fired power plant in Gisagara demonstrates the government's commitment to expanding peat utilization (World Bank, 2021).

One of the key contributions of peat to Rwanda's energy sector is enhanced energy security. Before the integration of peat power, Rwanda heavily depended on hydropower, which is vulnerable to seasonal fluctuations. By incorporating peat, the country has reduced its reliance on hydropower and minimized electricity shortages during droughts (MININFRA, 2020). Furthermore, peat-fired power plants have helped stabilize electricity supply, fostering industrial growth and attracting foreign investment.

Peat has also played a role in reducing Rwanda's reliance on imported petroleum products, which are subject to price volatility. By utilizing locally available resources, Rwanda has improved its trade balance and saved foreign exchange reserves that would otherwise be spent on fuel imports (AfDB, 2021). Despite its economic benefits, peat extraction and combustion raise environmental concerns.

Peatlands act as carbon sinks, and their degradation releases carbon dioxide and methane, contributing to greenhouse gas emissions (IPCC, 2019). Moreover, large-scale peat harvesting disrupts wetland ecosystems, affecting biodiversity and water regulation. To mitigate these effects, the Rwandan government has adopted strict regulations on sustainable peat harvesting and wetland restoration (REMA, 2021).

From a social perspective, the peat industry has generated employment opportunities in rural areas, contributing to poverty reduction. However, concerns have been raised regarding labor conditions in peat extraction sites. Ensuring fair wages, safe working environments, and community involvement in decision-making processes remains crucial for the sustainable development of the peat sector (ILO, 2020). Rwanda aims to balance its energy needs with environmental conservation.

Rwanda peat energy characteristics

Name of peat bog	Top soil depth (m)	Peat layer thickness (m)	*In-situ* moisture content (% wt)	*In-situ* bulk density (kg/m^3)	Average ash content in-situ peat, dry basis (% wt)	
Average values of all samples taken						Top soil layer not included
Cyato	2.5	2.4	74	1138	49	40
Murago	0.8	5.7	83	1056	42	31
Rucyahabi	1.8	3.7	80	1086	48	29
Akanyaru North (other), North	2.4	2.1	68	1180	66	46
Akanyaru North (other), Middle	0.8	4.6	78	1094	51	42
Akanyaru North (other, South)	0.3	7.6	85	1037	31	28
Bishya	1.2	2.4	70	1162	54	39
Akanyaru south (other)	0.3	7.8	83	1061	30	20
Mukindo	0.7	3.0	65	1207	64	43
Gishoma	0.7	2.2	73	1139	53	31
Gihitasi	0.6	2.0	73	1108	56	28
Mashya	0.0	3.5	86	1016	20	9
Kaguhu	0.9	0.9	53	1262	71	28
Bahimba	0.7	1.3	55	1297	75	42
Bisika	0.7	1.4	54	1278	77	73
Kageyo	1.3	1.0	53	1287	80	45
Ndongozi	0.1	2.9	76	1057	41	33
Nyirabirande	0.9	2.4	67	1162	57	32

Source : MUTEGERWA,2017

The government is exploring cleaner peat combustion technologies and integrating peat-based energy with renewable sources such as solar and geothermal. Additionally, reforestation and wetland restoration projects are being implemented to counteract peat extraction's environmental impact.

employment to the residents of Gisagara District, where it started employing more than 2,000 workers but is now being completed and employs more than 500 workers.

And it is expected that upon construction completion It will cost of more than four hundred million dollars ($ 400,000,000) which is about four hundred billion Rwandan francs.

Table 2:RWANDA ENERGY TREND

Table 2: Trends of energy mix per electricity generation from Q2 2022 to Q2 2023

Electricity generation mix	Q2 2022	Q3 2022	Q4 2022	Q1 2023	Q2 2023
Thermal (Fuel Oil)	18.86%	14.83%	17.66%	17.06%	8.96%
Hydro	51.76%	42.61%	49.67%	46.72%	50.61%
Methane	19.61%	19.37%	15.94%	16.66%	22.86%
Peat	5.27%	18.93%	12.70%	15.70%	11.27%
Solar	1.56%	1.63%	1.49%	1.43%	1.41%
Imports	2.94%	2.63%	2.55%	2.44%	4.89%

SOURCE: RURA,2023)

The 50.61% of electricity generation during the second quarter of 2023 are from Hydro, 8.96% from Thermal, 22.86% from Methane Gas, 11.27% from Peat, 1.41% from Solar energy and

4.89% are the imports. In general, the 52.02% of electricity generation in Q2 2023 are from renewable resources and 43.09% are from non-renewable resources whereas 4.89% are imported electricity. This shows that there is a high increase of peat energy generation that need to be stopped and renewable energy should be emphasized and developed to replace peat, as energy from renewable energy resources is highly increasing.

2.4. EMPRICAL REVIEW

The empirical review discusses the result and summary of findings of what the scholars and researcher had found related to reasons for phasing out the use of peat. Peat has traditionally been used as a fuel source in the energy sector, particularly in regions where it is abundant. However, due to its environmental impact, many countries are phasing out its use. This empirical review examines the reasons behind this shift, the processes involved, and the impacts on energy production and the environment.

Peatlands are critical carbon sinks, storing vast amounts of carbon that, if released, contribute significantly to greenhouse gas emissions. According to Joosten and Clarke (2002), peatlands store about 550 Gt of carbon, more than twice the amount stored in the world's forests. The extraction and burning of peat for energy release this stored carbon, exacerbating climate change (Assessment on Peatlands, Biodiversity, and Climate Change, 2008) Moreover, peatlands provide essential ecosystems for biodiversity, water regulation, and other ecological services. The degradation of peatlands for energy purposes leads to a loss of these services, further impacting the environment (Bragg & Tallis, 2001)

Finland has been one of the largest users of peat for energy in Europe. However, due to its high carbon intensity, the Finnish government has set targets to phase out peat use by 2030 (Ministry of Economic Affairs and Employment of Finland, 2020). This transition is supported by financial incentives for renewable energy investments and subsidies for restoring degraded peatlands (Michaux et al., 2023) Ireland has also significantly relied on peat for energy. The government has announced plans to cease peat-fired electricity generation by 2028. This decision is part of Ireland's broader strategy to reduce greenhouse gas emissions and promote sustainable energy sources (Department of Communications, Climate Action and Environment, 2018). The transition includes retraining programs for workers in the peat industry and investment in renewable energy sector

The phase-out of peat has significant economic implications, particularly for regions where peat extraction is a major industry. Job losses in the peat sector are a major concern (Adams &

Curtis, 2013). However, the transition to renewable energy sources can create new job opportunities. Governments are implementing policies to mitigate these impacts, such as retraining programs and financial support for affected workers and communities (O'Connor, 2020).

The transition from peat to renewable energy sources requires technological innovations and supportive policies. Advances in renewable energy technologies, such as wind, solar, and biomass, are essential to replace peat (Schilstra, 2001). Policy measures, including carbon pricing, subsidies for renewable energy, and regulations to protect peatlands, play a critical role in this transition (England Peat Action Plan, 2021).

Phasing out peat has numerous environmental benefits, including reduced greenhouse gas emissions, improved biodiversity, and restored peatland ecosystems (Worrall et al., 2010). Social benefits include improved air quality and public health (Health Impacts of Climate Change and the Health Benefits of Climate Change Action: A Review of the Literature, n.d.). The transition also aligns with global commitments to climate change mitigation, such as the SParis Agreement (Key Messages in Module 15, n.d.).

2.5. CONCEPTUAL FRAMEWORK

A conceptual framework is an abstract representation of the study's goals that guides the collection and analysis of data. In this research the concept will be highly focused on peat energy, contribution of peat energy in the environmental stress as well as carbon emissions of peat energy, phasing out time frame and socio- economic impact of phasing out the use of peat

2.6. Summary of the literature review

In different studies and in several countries of the world studies shows peat extraction and use are against the world agenda of clean energy and environmental protection, as the peatland is the home for ecosystem and biodiversity, peatland is also a sink for carbon dioxide and should be protected. From the overview this study intends to do analysis of different scenarios that can help the Rwanda police makers to phase out the use of peat in energy sector. It will also show in details how renewable energy will be good alternatives to replace peat, how they can tackle the soci0- economic impacts of peat phasing out.

CHAPTER 3. METHODOLOGY

3.1. INTRODUCTION.

Research methodology is a way to systematically solve the research problem. It may be understood as a science of studying how research is done scientifically. In it we study the various steps that are generally adopted by a researcher in studying his research problem along with the logic behind them(Patel & Patel, 2019).In this chapter I will cover the research design, targeted population, and sampling technics, data collection methods data collection instrument, reliability and validity, as well as ethical consideration within the research.

3.2. RESEARCH DESIGN

This study has adopted the quantitative method approach in the data gathering process.
This methodology usually investigates the "what, why, where and when" of the phenomena understudy to make decision (Noor, 2008) Quantitative research is based on the measurement of quantity or amount. Quantitative research conversely is concerned with quantities and measurements aimed at making scientific generalizations and predictions in a research activity.

VII. **Quantitative Research**

Quantitative Research is used to quantify the problem by way of generating numerical data or data that can be transformed into usable statistics. It is used to quantify attitudes, opinions, behaviors, and other defined variables and generalize results from a larger sample population. Quantitative research uses measurable data to formulate facts and uncover patterns in research. Quantitative data collection methods are much more structured than Qualitative data collection methods. Quantitative data collection methods include data from the previous researchers, government institution and company report.

3.2.1. VARIABLES OF INTEREST

In this study the analysis has focused economic social economic variables such as peat employment, peat energy and greenhouse gas emissions, and Renewable energy as an alternative for peat after phasing out.

3.2.2. Targeted Population and Sample Size

1. The targeted population for this study includes individuals (workers in peat industry), households (at least 2km from the peat power plant), and enterprises (micro businesses that are located near the peat power plant) that are directly or indirectly affected by the use and potential phase-out of peat energy in Rwanda. The groups were selected because they represent the main

socio-economic actors influenced by the transition from peat-based energy to renewable sources.

3.2.2.1. Sample size

Considering location of the peat power plant in Rwanda and the 200 people were taken as a population size and the following formula was used to calculate the sample size.

We can calculate the sample size using Yamane's formula:

$$n = \frac{N}{1 + N(e)^2}$$

Where:

- N=200N (population size)
- e=0.05 (margin of error, 5%)

1. Square the margin of error:

e^2=0.052=0.0025e^2

2. Multiply by population size:

N·e^2=200·0.0025=0.5N

Add1=1+0.5=1.5

n=200*1.5=133.3

Sample size (rounded): 133 respondents

3.3.DATA COLLECTION

Data was administered questionnaire and I have organized focus group discussion and interview system for data collection was used even the online calls where to get contact was possible, I use recording the answered to avoid the issue of language barriers to some respondent. I discussed with them the topics, the reason and they give me they feed back, and I record the answer for them. Observation technic has been used. End year energy report, after that data are organized in table format that make easy for analysis. Data such as energy statistic in Rwanda were collected from REG website, climate data and peat energy were collected from REMA and REG, summarized for analysis.

3.4.DATA ANALYSIS

I employed SPSS for my data analysis. SPSS is a software package used for statistical analysis, data management, and data visualization. It is widely used in social sciences, economics, health research, and other fields that require quantitative data analysis.

A flexible, scenario-based energy modeling tool for energy policy analysis and climate change mitigation planning is the LEAP (Long-range Energy Alternatives Planning) model. In order to comprehend the possible results of alternative energy strategies, LEAP enables users to construct and analyze many scenarios, such as business as usual versus different policy interventions. Because it may be used by non-experts, LEAP is a popular option for planners and policymakers (Nieves et al., 2019). Mirjat et al. (2015), in his study ‘Pakistan's Electricity Demand and Supply Scenarios (2015–2050)’ He found that the RET (Renewable energy technologies) scenario was the most sustainable, achieving a CO_2 reduction exceeding 50% by 2050. Emodi et al. applied LEAP to analyze Nigeria's future energy demand.

The Green Optimistic scenario projected an 11% reduction in emissions compared to the Reference scenario. I chose LEAP because it allows for scenario-based energy planning, enabling policymakers to assess the environmental, economic, and energy security impacts of transitioning from peat to alternative energy source

3.5. DESCRIPTION OF STUDY AREA

Rwanda has positioned itself as one of Africa’s fastest-growing economies, with key sectors including agriculture, tourism, and technology. The government promotes investment and entrepreneurship through policies that foster business growth. The country is also a leader in environmental conservation, with initiatives such as the ban on plastic bags and a strong commitment to reforestation and wildlife protection. Rwanda has a remarkable improvement in energy development perspective such as electricity access, energy supply and transmission to faster the economic growth.

peat energy has contributed to the reduction in electricity shortage as from 2010 Gishoma peat power plant has started with capacity of generating 15 MW as well as in 2017 HAQAN peat power plant started to generate about 80MW which remark a significant contribution to electricity access of 81% by 2024.

CHAPTER FOUR: RESULTS ANALYSIS

This chapter is used to analyze the data and discuss the implication of peat phasing out in Rwanda energy system and, what need to be done to curb these implication or effects.

Table 3:RWANDA LEAST COST ENERGY GENERATION BY 2050

Variable: Domestic production per Tecthnology and net Import: Final Energy Intensity (Gigawatt-Hour)
Scenario: Baseline,Scenario 1: Forecasted energy Production including Peat
Branch: Demand\Domestic production per Tecthnology and net Import
Region: Region 1

Branch	2025	2030	2035	2040	2045	2050
Hydro	706.1	1,174.4	1,715.8	2,464.2	2,464.2	2,464.2
Solar	56.1	333.7	461.7	698.5	758.1	2,658.5
Waste	-	-	278.6	278.6	278.6	278.6
Methane	542.8	692.7	901.2	901.2	874.4	875.6
Peat	122.8	216.3	216.3	413.4	681.5	715.6
Thermal	-	-	-	-	-	-
Natural gas	-	-	59.9	969.9	2,759.4	2,759.4
Nuclear energy	-	-	-	-	1,945.9	6,307.2
HydroPS	-	-	-	-	-	50.0
Geothermal	-	-	-	210.2	210.2	210.2
Consumer batt	-	-	-	-	-	91.0
Battery	-	-	-	-	-	2,628.0
Hydrogen	-	-	-	-	-	-
Wind	-	-	-	-	-	-
Net import	168.6	183.1	484.4	718.0	718.0	336.3
Total for Gwh needed in 2050 before peat phas	**1,596.4**	**2,600.2**	**4,117.9**	**6,654.0**	**10,690.3**	**19,374.6**

4.1. PEAT GENERATION CAPACITY IN FUTURE

The above table was the data from the Rwanda Energy Group and was entered in Leap to base on my analysis. as REG has forecasted the energy supply in year 2050, peat was included and is cleared seen that for them to maximize energy supply peat is expected to be among the dominant energy sources as it will produce about 715.6 GWh in 2050.but as we have said to support also the vision 2050 of Government of Rwanda of achieving a target of zero emission and clean energy. According to Rwanda Green Fund Rwanda want to reduce greenhouse gas emissions by 38% in 2030. To support this based on the CO2 and other gas emitted from peat in combination of environment problem of peatland destruction through peat extraction. I took it as my concern that peat should be phased out and replaced by increasing investment in our dominants renewable energy sources including Solar, Hydro energy and also Geothermal energy.

4.2. ENERGY SECTOR LOOK LIKE AFTER PEAT PHASING OUT

Table 4:SCENARIO 1. PEAT PHASING OUT BY 2040

Variable: Domestic production per Tecthnology and net Import: Final Energy Intensity (Gigawatt-Hour)
Scenario: Baseline
Branch: Demand\Domestic production per Tecthnology and net Import
Region: Region 1

Branch	2025	2030	2035	2040	2045	2050
Hydro	706.1	1,174.4	1,715.8	2,464.2	2,464.2	2,464.2
Solar	56.1	333.7	461.7	698.5	758.1	2,658.5
Waste	-	-	278.6	278.6	278.6	278.6
Methane	542.8	692.7	901.2	901.2	874.4	875.6
Peat	122.8	100.0	40.0	-	-	-
Thermal	-	-	-	-	-	-
Natural gas	-	-	59.9	969.9	2,759.4	2,759.4
Nuclear energy	-	-	-	-	1,945.9	6,307.2
HydroPS	-	-	-	-	-	50.0
Geothermal	-	-	-	210.2	210.2	210.2
Consumer batt	-	-	-	-	-	91.0
Battery	-	-	-	-	-	2,628.0
Hydrogen	-	-	-	-	-	-
Wind	-	-	-	-	-	-
Net import	168.6	183.1	484.4	718.0	718.0	336.3
Total energy production with Peat phased out in 2040	**1,596.4**	**2,483.9**	**3,941.6**	**6,240.6**	**10,008.8**	**18,659.0**

Table shows the results after peat is phased out in 2040.

After peat is removed from the energy source in Rwanda by 2040.It’s clear that the forecasted energy by Rwanda energy group will immediately reduce by some GWh every year up to 2050. This reduction has no highly impacted because With the overall average growth of 8.44% over the past 25 years consistent with the implementation of the current strategic plan, 9.20% demand growth during 2017- 2023, a 10% annual electricity demand growth rate is used for Rwanda’s generation expansion scenario development and expansion planning with sensitivity analyses conducted on a bound between 5% and 10% annual demand growth since 2030 (REG REPORT ,2023) with reference of 9.2% increase of energy demand in 2017, there have forecasted energy demand by using 10% growth in energy demand to be about 16720 GWh ,due to this phasing out may have no more significant impacts to the energy system of Rwanda . But to account for energy efficiency,

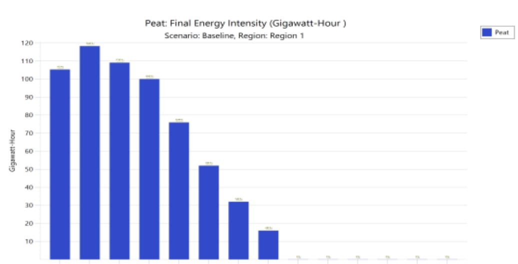


Figure 4. PEAT PHASING OUT BY 2040

energy loses through all channels of transmission and distribution I have suggested what need to be done to increase the electricity generation to the level of forecasted electricity generation by 2050 by REG.

4.3. ENERGY SHORTAGE AFTER PEAT PHASING OUT BY 2040

Table 5: DISCREPENCIES IN ENERGY GERATION AFTER PEAT PHASING OUT

Variable: Domestic production per Tecthnology and net Import: Final Energy Intensity (Gigawatt-Hour)
Scenario: Baseline,combined scenarios before and afetr peat is phased out in 2050
Branch: Demand\Domestic production per Tecthnology and net Import
Region: Region 1

Branch	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
Hydro	706.1	1,174.4	1,715.8	2,464.2	2,464.2	2,464.2
Solar	56.1	333.7	461.7	698.5	758.1	2,658.5
Waste	-	-	278.6	278.6	278.6	278.6
Methane	542.8	692.7	901.2	901.2	874.4	875.6
Peat	122.8	216.3	216.3	413.4	681.5	715.6
Thermal	-	-	-	-	-	-
Natural gas	-	-	59.9	969.9	2,759.4	2,759.4
Nuclear energy	-	-	-	-	1,945.9	6,307.2
HydroPS	-	-	-	-	-	50.0
Geothermal	-	-	-	210.2	210.2	210.2
Consumer batt	-	-	-	-	-	91.0
Battery	-	-	-	-	-	2,628.0
Hydrogen	-	-	-	-	-	-
Wind	-	-	-	-	-	-
Net import	168.6	183.1	484.4	718.0	718.0	336.3
Total for Gwh needed in 2050 before peat phased out	**1,596.4**	**2,600.2**	**4,117.9**	**6,654.0**	**10,690.3**	**19,374.6**
Total GWh after peat is phased out	**1,596.4**	**2,483.9**	**3,941.6**	**6,240.6**	**10,008.8**	**18659**
Total difference of the Two scenarios	**-**	**116.30**	**176.30**	**413.40**	**681.50**	**715.60**

After phasing out peat in the energy sector, even though calculation those there are no impacts on Energy demand because, Total energy production also will continue to be above the energy demand through -out the year 2050.

below is the table for some assumption on the sectors of energy production to compensate for the GWh that will be lost when the peat energy is phased out in Rwanda energy sector

4.4. TRANSITION TO RENEWABLE ENERGY BY 2050

Table 6: PEAT TRANSITION TO RENEWABLE ENERGY

Variable: Domestic production per Tecthnology and net Import: Final Energy Intensity (Gigawatt-Hour)
Scenario: Baseline
Branch: Demand\Domestic production per Tecthnology and net Import
Region: Region 1

Branch	2025	2030	2035	2040	2045	2050
Hydro	706.1	1,274.4	1,915.8	2,664.2	2,754.2	2,964.2
Solar	56.1	433.7	461.7	798.5	1,158.1	2,873.5
Waste	-	-	278.6	278.6	278.6	278.6
Methane	542.8	692.7	901.2	901.2	874.4	875.6
Peat	122.8	100.0	40.0	-	-	-
Thermal	-	-	-	-	-	-
Natural gas	-	-	59.9	1,083.9	2,759.4	2,759.4
Nuclear energy	-	-	-	-	1,945.9	6,307.2
HydroPS	-	-	-	-	-	50.0
Geothermal	-	-	-	210.2	210.2	210.2
Consumer batt	-	-	-	-	-	91.0
Battery	-	-	-	-	-	2,628.0
Hydrogen	-	-	-	-	-	-
Wind	-	-	-	-	-	-
Net import	168.6	183.1	484.4	718.0	718.0	336.3
Total energy supply after assumptions to compansat	**1,596.4**	**2,683.9**	**4,141.6**	**6,654.6**	**10,698.8**	**19,374.0**

Given the assumption that ,to compensate for the forecasted GWh for peat ,the government of Rwanda through the Ministry of Infrastructure,RURA (Rwanda Utility Regulatory Agency) , and REG(Rwanda Energy Group),as to focus on the Other source of energy mainly Hydro and Solar and Geothermal energy sources, Based on the REG report of energy plan of the least cost energy sources ,Hydro was forecasted to Generate about **1174.5,1715.8,2464.2,2464.2,2464.2,**2464.2 all in GWh **2020,2035,2040,2045,2050** respectively. to increase by 200,200,200,290, and 500 GWh in 2030,2035,2040,2045,2050 Respectively. And also, the Other emphasis should to focus and invest in PV or solar energy to Increase the energy from it more than forecasted at least to add 150GWh.

4.5. ROLE OF PEAT ENERGY TO THE GREENHOUSE GAS EMMISSIONS

GHGs (Greenhouse gas emissions are the dangerous to the environment and has more impacts to the climate change over the years by using the IPCC emission factor.

Emission gas	Impacts Categories	Quantities measured	Percentage emission	Total measured for 15 Mwh	Standard Quantities (g/MJ)
CO_2	GWP	104.2 g/h	80.30%	5617080	106
CH_4	GWP	5 g/h	3.85%	270	8.7802
NO_2	Acidity	6 g/h	4.62%	324	10.999
SO_2	Acidity	14.56 g/h	11.23%	77000	20

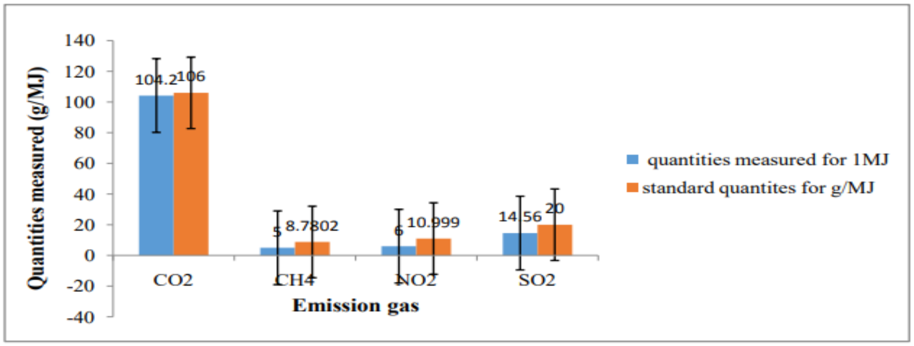


Figure 5:EMISSION ON THE FIELD

SOURCE: (HAFASHIMANA ,2019)

Given the above emission calculated, the they use only the gases fluxes at the site in the process conversion ,and as results to get all the emission from peat I have used the emission factors from IPCC 2006,as Rwanda has no specific emission factors to estimate the emissions from peat even though this had covered only the the Gishoma peat power plant while Rwanda has approximately 155 million peat bogs covering 50,000 ha,and is capable of generating 1200MW .So to capture full insight I have chosen to use the IPCC emission factor.

I have used Tier 1 formula to compute predicted emission from peat given the forecasted energy from peat.

Emissions GHG, $_{\text{fuel, technology}}$ =Fuel Consumption $_{\text{fuel, technology}}$ *Emission Factor GHG, $_{\text{fuel, technology}}$

from the IPCC emission factor information, the peat land emission factor

4.6. Peatland Emission Factors

Peatland emission factors are typically derived from empirical studies and are often region-specific due to the variability in environmental conditions. Several international databases, such as the Intergovernmental Panel on Climate Change (IPCC) guidelines and national carbon accounting systems, provide default emission factors for peatlands (IPCC, 2006). These factors are based on data collected from long-term field studies and experiments that quantify emissions from different peatland types and management practices.

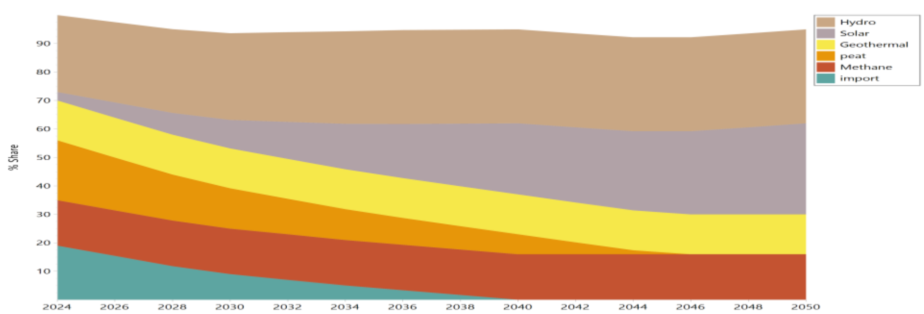
of disturbance.

The IPCC provides emission factors for drained organic soils, which typically have higher CO2 emissions compared to natural, undisturbed peatlands (IPCC, 2006). A study in Indonesia found that CO2 emissions from drained peatlands were significantly higher than from undisturbed peatlands, with annual emissions ranging from 200 to 1,000 g CO2/m² (Houghton et al., 2012). Similarly, peat extraction operations, which involve the removal of peat for fuel or horticultural purposes, can release large amounts of CO2, with emissions varying depending on the extent

Table 7:FORECASTED CO2 EMISSION FROM PEAT BY 2050 FOR THE PEAT ENERGY CONSUMED

Year	Peat **ENERGY IN GWH**	**PEAT ENERGY IN TJ**	**EF FOR PEAT IN**	**MT CO2 Eq /TJ**
2024	105.3	379.1	**2.00**	**758.16**
2025	122.8	442.1	**2.00**	**884.16**
2030	216.3	778.7	**2.00**	**1557.36**
2035	216.3	778.7	**2.00**	**1557.36**
2040	413.4	1488.2	**2.00**	**2976.48**
2045	681.5	2453.4	**2.00**	**4906.8**
2050	715.6	2576.2	**2.00**	**5152.32**
	1GWH=3.6TJ			

FIGURE ENERGY SUPPLY MIX



SOURCE: Generated by researcher.

Using the IPCC emission factor from managed peatland and tier 1 formula for emission calculation it is clearly shown that the Rwandan target to increase the energy production by 2050 will results to the emission of 5.152 MT of CO2 equivalent emission per unit of energy consumed which is TJ. so it is essential that for Rwanda in line of its vision 2035 and 2050 with sustainable environment and clean energy adaptation peat need to be phased out and replaced with other renewable energy as indicated to avoid such kind metric tons of emissions from it

Table 8: TOTAL EMISSION FROM PEAT IN 2050 PER UNITS OF PEAT ENERGY CONSUMED

Year	Peat ENERGY IN GWH	PEAT ENERGY IN TJ	MT CO2 Eq /TJ	MT NO2 Eq /TJ	MT CH4 Eq /TJ	TATAL
2024	105.3	379.1	758.16	682.34	568.62	2,009.12
2025	122.8	442.1	884.16	795.74	663.12	2,343.02
2030	216.3	778.7	1,557.36	1,401.62	1168.02	4,127.00
2035	216.3	778.7	1,557.36	1,401.62	1168.02	4,127.00
2040	413.4	1488.2	2,976.48	2,678.83	2232.36	7,887.67
2045	681.5	2453.4	4,906.80	4,416.12	3680.1	13,003.02
2050	715.6	2576.2	5,152.32	4,637.09	3864.24	13,653.65
	1GWH=3.6TJ	CO2 EF FOR PEAT:2				
		NO2 EF FOR PEAT AND :1.8				
		CH4 EF FOR PEAT;1.5				

Even though energy is crucial for economic growth and development it is observed that peat in terms of environment cleanliness ,peat cannot be continued to be taken as clean energy .Because it is clearly seen that its contribute more to major green gas emissions as it is forecasted to emit 13.65 Mt of gas fluxes by 2050.these emission will be emitted while all preventive measures are used ,the main cause of not avoiding gases is that peat energy are mostly find and stored during the dry season .and gas during extraction cannot be prevented.

4.7. SOCIO-ECONOMIC EFFECT OF PEAT PHASING OUT IN THE ENERGY SECTOR IN RWANDA

4.7.1. SCENARIO 2. SOCIO -ECONOMIC EFFECTS OF PEAT PHASING OUT.

*Table 9**: SUMMARY STATITSICS FROM SPSS***

	age	monthly_income in RWF	peat_dependence_1_5	support_phasing_1_5	willing_pay_more_pct
count	133.00	133.00	133.00	133.00	133.00
mean	37.25	45,000.00	1.38	3.48	5.42
std	10.70	38,500.00	1.87	1.37	5.37
min	18.00	32,300.00	-	1.00	-
0.25	31.00	29,000.00	-	2.00	-
0.50	37.00	80,000.00	-	4.00	5.00
0.75	43.00	240,000.00	3.00	5.00	10.00
max	68.00	280,000.00	5.00	5.00	20.00

Source: Generated from SPSS by a researcher.

The respondents are mostly middle-aged adults, with a relatively even distribution from young adults to older adults. The respondents' income varies widely, with many earning around 280,000 RWF per month. The spread suggests some inequality in earnings. Most respondents report low dependence on peat energy, but a few are highly dependent. Respondents generally support phasing out peat, though some are neutral or less supportive. Mean: 5.42%, indicating respondents are willing to pay on average 5.42% more for alternatives, Std: 5.37%, high relative to the mean, showing wide variation in willingness.

PEOPLE 'S AWARENESS ABOUT ENVIRONMENTAL IMPACTS OF PEAT ENERGY		
DECISION	**count**	**percent**
Yes	**98**	**77.5**
No	**35**	**22.5**

I

In this survey the results shows that 22.5% are have no information about the impacts of peat energy. And 77.5 %are aware of the environmental impacts of peat energy and support peat phasing out after having reliable energy alternatives. Phasing out peat will significantly reduce CO2 emissions and air pollution, leading to improved public health and reforestation efforts. The socio-economic impact of peat phasing out in Rwanda presents both challenges and opportunities. While job losses and higher energy costs are immediate concerns, increased investments in renewable energy, improved environmental conditions, and expanded electricity access highlight the long-term benefits. Government policies should focus on job transition strategies and energy affordability measures to ensure a smooth transition.

support_phasing_1_5	count	percent
1	13	10.8
2	25	16.7
3	28	17.7
4	30	25
5	37	30.8

uses_peat	count	mean
No	83	3.29
Yes	50	3.79

support_status	percent
Support	55.8
Not support	44.2

In this research the overall pictures from the population studied 30.8% of the total population strongly support the peat energy phasing out while 10.8% are against peat energy phasing out due to high dependence on its, especially employment level.

Indicator	Value
Sample size	133
Mean age (years)	37.2
Female (%)	52.5
Tertiary education (%)	34.2
Uses peat (%)	39.2
Support phasing (>=4) (%)	55.8
Mean peat dependence (users only, 1-5)	3.53
Have access to alternative energy (%)	45.8
Concerned about job impacts (%)	55
Median monthly income (Rwf)	45000

This is the overall summary indicate that some people are against phasing out but also a high percentage support this motion. People are against it because of income dependence on peat power plants, such as employment, but due to its is affected by the seasonal change if government continues mobilization towards other alternative energy sources ,they are a high probability of giving up the peat energy.

4.8. STAKEHOLDER ENGAGEMENT IN PEAT PHASING OUT

Involving people, groups, and organizations that are interested in or impacted by a project, policy, or decision is known as stakeholder engagement. It is essential to public policy, business, and governance since it makes sure that many viewpoints are considered when making decisions (Freeman, 1984). Investment strategies and policy direction in renewable energy are within the purview of the Ministry of Infrastructure (MININFRA). Environmental laws are enforced and compliance is tracked by the Rwanda Environment Management Authority (REMA). Private sector investment in clean energy initiatives is facilitated by the Rwanda Development Board (RDB).

Companies involved in peat extraction must transition their business models toward renewable energy. Financial institutions should provide green financing options for renewable energy projects. Industrial sectors relying on peat should be supported in adopting sustainable alternatives through incentives.

support policy implementation and social protection measures, climate finance mechanisms such as the Green Climate Fund (GCF) can fund sustainable energy projects.

CHAPTER 5: CONCLUSION AND RECOMMANDATION

5.1. SUMMARY

Energy is important for boosting economic growth and development, every government of country made energy a priority for development including Rwanda, for Rwanda to increase energy access to all Rwandans, two peat power plant has started operation and its generation 95Mw.In order to make the clean energy system, Rwanda has put emphasis on solar and hydro power energy generation system.

Although my research revealed that peat is not a clean energy because I have found that through its extraction process and combustion it has a capacity of emitting over than 13Mt of greenhouse gases that are dangerous to the environment. Electricity access will increase from 81.4% to 100% due to that government plan to increase off- grid connection, cost of electricity in short -run will increase per households but in in long-run it will converge. Employment in the energy sector have to reduce due to phaseout but in long run, transition will cover the gap.

Based also on my finding phasing out the use of peat will affect Rwanda energy sector as peat energy was no longer there, people depending on this kind of energy and peat in as row material in other ways such as CIMERWA and bricks making company will be directly affected, as well as people employed in this sector both formally and informally. To avoid

5.2. CONCLUSION

The gradual elimination of peat use in Rwanda energy sector represents an important turning point regarding the country ‘s sustainable development and environmental policy. This shift not only demonstrates the need for additional energy services, but also show case a widening scope for protection of the environment and population health. As Rwanda moves to a power renewable based fuels mix, the opportunity for increased economic competitiveness emerges because of the global emphasis on reducing greenhouse gas emissions should the planned reforms be successfully implemented.

Rwanda could achieve greater integration with global market through nontariff trade mechanisms which previously helped developing nations especially those in Africa. according to Amjad et Al, the protection focus on ecosystem will improve Rwanda standing in the environmental performance index which will support its goal to maintain a healthy environment while meeting increasing energy supply and demands. by conclusion peat era represent an energy policy transformation coupled with the movement towards a more sustainable and economically beneficial nation. the analysis of Rwanda ‘s energy sector development and post peat phasing out demonstrates its potential to strengthen its role within international energy supply networks.

5.3. RECOMMENDATIONS

Peat is a significant source of energy in Rwanda, primarily used for electricity generation and industrial applications. However, its environmental impact, particularly its contribution to greenhouse gas emissions and land degradation, necessitates a strategic phase-out. This report presents detailed recommendations for the Rwandan government and researchers to facilitate a smooth transition away from peat.

5.3.1 Recommendations for the Government of Rwanda

s5.3.2. Policy and Regulatory Framework

Develop and implement a national peat phase-out policy with clear targets and timelines. Strengthen environmental regulations to restrict new investments in peat extraction and usage. Introduce carbon pricing or taxes on peat-based energy to encourage alternative energy investments. Foster international partnerships for technology transfer and financial support.

5.3.3. Investment in Renewable Energy Alternatives

Scale up investments in solar, hydro, and wind power to replace peat in the national energy mix. Provide incentives and subsidies for industries transitioning to renewable energy. Establish a national research and development fund dedicated to clean energy innovation.

5.3.4 Socioeconomic Transition and Job Creation

Implement reskilling programs for workers currently employed in the peat sector. Support alternative employment opportunities in green industries such as sustainable forestry and renewable energy. Ensure that local communities benefit from alternative energy projects through community-based energy initiatives.

5.4 Recommendations for Rwandan Researchers

Research and document the environmental, economic, and social impacts of peat phase-out. Analyze the long-term cost-benefit of transitioning to renewable energy sources. Study the effects on biodiversity and water resources to inform sustainable land restoration efforts.

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Appendix

ELECTRICITY FORECASTED BY REG

EXISTING GENERATION CAPACITY

No	Plant Name	Installed Capacity (MW)	Capacity Factor (%)	Available Capacity (MW)	Owner	COD	Type of Technology
1	Ntaruka	11.25	33.61	3.8	GoR	1959	Hydro
2	Mukungwa I	12	61.56	7.4	GoR	1982	Hydro
3	Nyabarongo I	28	68.54	19.2	GoR	2014	Hydro
4	Gisenyi	1.7	65	1.1	Prime Energy Ltd	1957	Hydro
5	Gihira	1.8	70	1.3	RMT	1984	Hydro
6	Murunda	0.1	45	0.0	Repro	2010	Hydro
7	Rukarara I	9	40	3.6	Ngali Energy	2010	Hydro
8	Rugezi	2.6	50	1.3	RMT	2011	Hydro
9	Keya	2.2	50	1.1	Adre Hydro&Energicotel	2011	Hydro
10	Nyamyotsi I	0.1	0	0.0	Adre Hydro&Energicotel	2011	Hydro
11	Nyamyotsi II	0.1	0	0.0	Adre Hydro&Energicotel	2011	Hydro
12	Agatobwe	0.39	35	0.1	Carera-Ederer	2010	Hydro
13	Mutobo	0.2	45	0.1	Repro	2009	Hydro
14	Nkora	0.68	50	0.3	Adre Hydro&Energicotel	2011	Hydro
15	Cyimbili	0.3	50	0.2	Adre Hydro&Energicotel	2011	Hydro
16	Gaseke	0.5	90	0.5	Novel Energy	2017	Hydro
17	Mazimeru	0.5	49	0.2	Carera-Ederer	2012	Hydro
18	Janja	0.2	80	0.2	RGE Energy UK ltd	2012	Hydro
19	Gashashi	0.28	40	0.1	Prime Energy Ltd	2013	Hydro
20	Nyabahanga I	0.2	55	0.1	GoR	2012	Hydro
21	Nshili I	0.4	0	0.0	GoR	2012	Hydro
22	Rwaza Muko	2.6	60	1.6	Rwaza HydroPower Ltd	2018	Hydro
23	Musarara	0.4	49	0.2	Amahoro Energy	2013	Hydro
24	Mukungwa II	3.6	73	2.6	Prime Energy Ltd	2013	Hydro
25	Rukarara II	2.2	52.5	1.2	Prime Energy Ltd	2013	Hydro
26	Nyirabuhombohombo	0.65	35	0.2	RGE Energy UK ltd	2013	Hydro
27	Giciye I	4	40	1.6	RMT	2013	Hydro
28	Giciye II	4	40	1.6	RMT	2016	Hydro
29	Giciye III	9.8	40	3.9	RMT	2020	Hydro

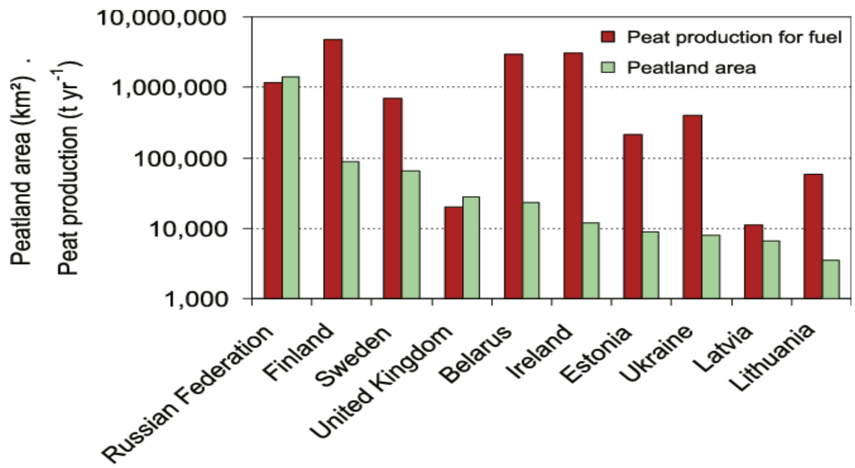
GISHOMA PEAT POWER PLANT MAIN CHARACTERISTICS

Parameter	Value	Unit
Technology Name	**Peat Power Plant**	**-**
Total Installed Capacity	**95**	**MW**
Availability Factor	**0.9 - 1.0**	**Fraction**
Load Factor	**0.85 - 0.95**	**Fraction**
Efficiency	**35 - 40%**	**%**
Lifetime	**30**	**Years**
Heat Rate	**10,000 - 11,000**	**kJ/kWh**

s	1269.7	1427.9	2417.2	3633.5	5936.0	9972.4	19036.5
Hydro	669.0	706.1	1,174.5	1,715.8	2,464.2	2,464.2	2,462.4
Solar	56.1	56.1	333.7	461.7	698.5	758.1	2,658.5
Waste/Biomass	.	.	.	278.6	278.6	278.6	278.6
Methane	439.3	542.8	692.7	901.2	901.2	874.4	875.6
Peat	105.3	122.8	216.3	216.3	413.4	681.5	715.6
Thermal	.	.	.	.	.	.	.
Natural Gas	.	.	.	59.9	969.9	2,759.4	2,759.4
Nuclear	.	.	.	.	.	1,945.9	6,307.2
HydroPS	.	.	.	.	.	.	50.0
Geothermal	.	.	.	.	210.2	210.2	210.2
Consumer Batt	.	.	.	.	.	.	91.0
Batterv	.	.	.	.	.	.	2,628.0
Hydrogen	.	.	.	.	.	.	.
Wind	.	.	.	.	.	.	.
Import/Export	170.3	168.6	183.1	484.4	718.0	718.0	336.3
Import	185.0	187.1	201.0	502.2	735.8	735.8	354.2
Export	{14.7)	(18.4)	(17.9)	(17.9)	(17.9)	{17.9)	{17.9)
Total Supply	1439.9	1596.5	2600.3	4117.8	6653.9	10690.4	19372.9

PEAT ENERGY DATA FROM REG CONSOLIDATED REPORT OF 2024

Details	Hydro	Methane	Thermal	Solar	Peat	Import	Shared	Total
2015-2016	271.9	114.5	174.5	13.9	1.4	56.9	18.9	**652.1**
2016-2017	277.2	197.6	129.6	14.5	14.3	22.9	56	**712.1**
2017-2018	333.8	195	138.7	16.9	15.3	31.5	50.2	**781.4**
2018-2019	337.5	213.1	158.7	18.1	31	32	63.9	**854.2**
2019-2020	387	213.6	135.9	17.7	19	30.2	69.2	**872.6**
2020-2021	494.4	206.8	92.7	18.1	30.6	29.7	82.3	**954.7**
2021-2022	461.52	218.6	194.51	17.53	80.9	31.98	64.56	**1,069.58**
2022-2023	494.02	225.04	174.43	17.83	174.85	37.84	75.32	**1,199.33**
2023-2024	518.48	434.17	11.83	17.83	107.05	135.23	141.81	**1,366.39**
Contribution to energy Mix (%)	**37.95**	**31.77**	**0.87**	**1.30**	**7.83**	**9.90**	**10.38**	**100%**



QUESTIONS ASKED IN THE INTERVIEW.

Questionnaire: Peat Phasing Out in Rwanda Energy Sector

Target sample size: 133 respondents

Objective: To collect data on household and worker perceptions, awareness, and impacts of peat phasing out in Rwanda's energy sector.

Section A — Identification

1. Respondent ID

2. Interview date
3. Location (District / Sector / Village)
Section B — Demographics
4. Age (years) — Numeric
5. Gender — Male / Female / Other
6. Highest education level completed
No formal education / Primary / Secondary / Tertiary
7.Main occupation
Farmer / Energy worker / Small business / Household worker / Other
8. Approx. monthly household income in RWF

Section C — Peat Use and Dependence

1. 9. Do you or your household use peat for energy? —s Yes / No
2. 10. If yes: On a scale 1–5, how dependent is your household on peat for daily energy needs? (1 = very low, 5 = very high). If no, record 0.

Section D — Awareness & Attitudes

3. 11. Have you heard of plans to phase out peat (or reduce peat use) in Rwanda? Yes/ No
4. 12. To what extent do you support phasing out peat? (1 = strongly oppose ... 5 = strongly support)
5. 13. What economic impact do you expect from phasing out peat? — Positive / Neutral / Negative

Section E — Alternatives & Cost Willingness

6. . Do you currently have access to affordable alternative energy (e.g., electricity, LPG, modern biomass)? — Yes / No

7. 15. If alternatives cost more, would you be willing to pay more? If yes, how much more (%) of current energy expense would you accept? (numeric, 0 if none)
8. **Section F — Social / Employment Impacts**
9. 16. Do you expect peat-phasing to affect jobs in your household or community? — Yes / No
10. 17. Which support would you prefer if peat is phased out? — Subsidies for alternatives / Training & re-skilling / Cash compensation / Community projects / No support needed

Section G — Optional

18. Short comments / suggestions — (text)