Energy Security:
Global analysis of Energy Matrix demand Mozambique case

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May 28th, 2024

Keywords: Energy system modelling, energy security, energy transition, renewable energy, climate change, OSeMOSYS.

Acknowledgements

We would like to thank Fernando Antonio Plazas Niño, Pacifique Koshikwinja Matabishi, Pedro Henrique Peters Barbosa, Simone Osei-Owusu, and the whole team from Climate Compatible Growth, United Nations Energy Commission for Africa, Ministry of Energy Ghana, the Ghana Energy Commission, Ghana Atomic Energy Commission, Ghana Institute of Management and Public Administration, and The Brew-Hammond Energy Centre at Kwame Nkrumah University of Science and Technology as the organisers for supporting the development of this work.

This material has been produced with support from the Climate Compatible Growth (CCG) programme. CCG is funded by UK aid from the UK government. However, the views expressed herein do not necessarily reflect the UK government's official policies.

ABOUT EMP-A,

The Energy Modelling Platform for Africa's main objective is to contribute to creating optimised investments for the energy transition in Africa to meet the continent’s growing demand for low-carbon, inclusive, and climate-resilient development pathways whilst accessing its large resource base. Furthermore, almost all African countries have included renewable power generation in their Nationally Determined Contributions (NDCs) to climate action under the Paris Agreement on climate change framework. The prominence of renewable energy in these actions, coupled with Africa’s abundant renewable energy resources (including variable renewable energy sources such as wind and solar) and the urgent need to mobilise investments to meet a considerable energy deficit on the continent, requires strategic assessment planning. This platform is an excellent opportunity to acquire training, access to discussion forums, and coaching skills in models and tools for energy planning needs.

Executive Summary

Energy production in Mozambique grew by 61% from 2015 to 2020, reaching 18 million tons of oil equivalent (Mtoe), representing a growth only in fossil fuels of 53% of total energy production, with emphasis on the contribution of natural gas and the exploration of mineral coal by 19% and 34%, respectively. In terms of domestic production, biofuels (bagasse and woody biomass) represent a greater contribution with 41%.

In this context, three scenarios were designed, including Business As Usual (**BAU**), Energy Transition (**ET**) and Energy Security (**ES**) with a view to achieving Universal access by 2030.

Key Findings

1. This comprehensive approach ensures strategic planning and prioritisation of projects to meet future energy needs and enhance Mozambique's role in regional energy production; and,
2. These three (3) scenarios help in understanding the implications of different energy strategies and in making informed decisions for Mozambique's energy planning.

Recommendations

For future work, our focus will be on several key areas to enhance the comprehensiveness and accuracy of our data and analysis. Here is a detailed plan:

1. Disaggregating Input Data from Different Primary Sources;
2. Collecting Data Information about Electricity Generation and Capacity of Stand-Alone Systems and Sugar Mills; and,
3. Analysing Data Costs of Different Technologies.

By focusing on these areas, we aim to provide a robust analysis that can guide policy-making, investment decisions, and further research in the field of electricity generation and technology costs.

1. Introduction

Mozambique is dedicated to achieving universal energy access by 2030, primarily through the construction of new electrical energy production plants from an energy transition standpoint. This strategy aims to enhance energy security by diversifying energy sources and investing in the sustainable utilisation of resources like natural gas, water, and mineral coal. Specifically, there is a focus on adopting lower-cost technological approaches to generate electricity from mineral coal, aligning with planned demand for the foreseeable future.

Purpose and Scope

Mozambique is a country in transition that is committed to rapid progress and economic growth, through increased job creation for young people and a growing population. The Government of Mozambique is committed to achieving the goal of universal access to energy by 2030 and, to this end; energy must be affordable and sustainable. Endowed with a diverse and vast energy matrix (hydro, mineral coal, natural gas, solar and wind), far above what is necessary to satisfy domestic demand in the coming decades that places the country in a good position to provide low-cost solutions for the region.

Investments in energy projects are essential to ensure adequate planning of the production capacity necessary to cover demand and to guarantee the creation of corridors for the transmission of energy from production centres to load centres.

The execution of projects in BAU, ET and ES was based on resilience to climate change to allow Mozambique to invest in other areas that have not yet been reached. The expansion of electricity production, transmission and distribution will contribute to increasing access to energy and strengthening regional integration.

The document outlines the imperative to optimise investments in the National Electric Grid to support new connections under various programs such as Energy for All, Electrification of Administrative Posts, and development projects in tourism, agriculture, and mineral exploration. These initiatives aim to boost the country's economy through industrialization, aligning with the Government and EDM's goal of ensuring electricity access for the Mozambican population by 2030. This effort also contributes to achieving the 17 Sustainable Development Goals outlined in the 2030 Agenda.

The portfolio of priority projects, used to create the Energy Transition (ET) and Energy Security (ES) scenarios, was developed through:

(i) Evaluating trends in electricity demand growth;

(ii) Discussing strategies to balance electricity supply with demand;

(iii) Assessing electrical energy demand based on established planning criteria;

(iv) Identifying and analysing opportunities to implement structured energy production projects; and,

(v) The aiming to transform Mozambique into a significant electrical energy generation hub within the region.

Modelling Premises, Objectives and Aims

Population increase rate of 2.1% - 2.7% if from 2021 to 2030;

Expanding Access: Achieve universal access by 2030.

Diversification of the energy matrix (generation using different production sources, ex. 70% from renewables), priorities and sequence.

Research Questions

What will be the energy mix taking into account the generation and installed capacity by improving the energy access?

2. Methodology

The Mozambican is 2021-2030 Priority Projects serve as a reference for future projections and aim to define the key projects needed to prepare the electrical system for new connections under the Energy Program for All. These priority projects provide a foundational basis for projecting future energy needs and developments. They focuses on organizing the electrical system to manage new connections facilitated by the Energy Program for All.

The OSeMOSYS Model was selected for long-term energy system analysis in order to identifies the optimal evolution of energy-technology combinations and ensures that the energy system evolves at minimum cost while adhering to greenhouse gas (GHG) emission limits.

For projections, three scenarios were analysed, including the BAU scenario, Energy Transition scenario and Energy Security scenario. **Figure 1** summarises the conceptualization and aims that the 3 scenarios will analyse.

Business As Usual Scenario (represents a continuation of current policies and trends without significant changes and aims to provide a benchmark for comparison with other scenarios):

- This scenario acts as a baseline, projecting the energy transition while maintaining existing technologies and conditions from previous years. It involves low adoption rates of new technologies such as solar thermal, nuclear, and offshore wind, lacks emission caps, and relies on energy carriers based on historical trends.

Energy Transition Scenario (focuses on shifting towards renewable energy sources and reducing reliance on fossil fuels and aims to analyse the impacts of transitioning to a more sustainable and environmentally friendly energy system):

- The goal of the "Energy transition scenario" is to pinpoint the sequence of investments in energy production and transport projects to ensure sufficient energy availability to meet demand. This includes designing transmission corridors from production centers to load centers. Realistic production scenarios were established by weighing production potentials against demand growth trends, as well as considering their geographical alignment with energy production potential.

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Energy Security Scenario (emphasizes ensuring a stable and reliable energy supply, possibly through diversification of energy sources and enhancing energy infrastructure, and aims to explore strategies for achieving energy security and resilience against potential disruptions):

- The Energy Mix Scenario is crucial for ensuring consistent production capacity throughout the year, leveraging Mozambique's abundant but underutilised primary resources. Efforts will be made to enhance energy supply from diverse sources to diversify supply and meet future demand projections. Total capacity must be ample to handle peak demand with acceptable reliability levels. Given that certain production units may face variable generation due to limited primary energy sources, it's essential to have reserve production capacity to meet demand during such instances of unavailability.

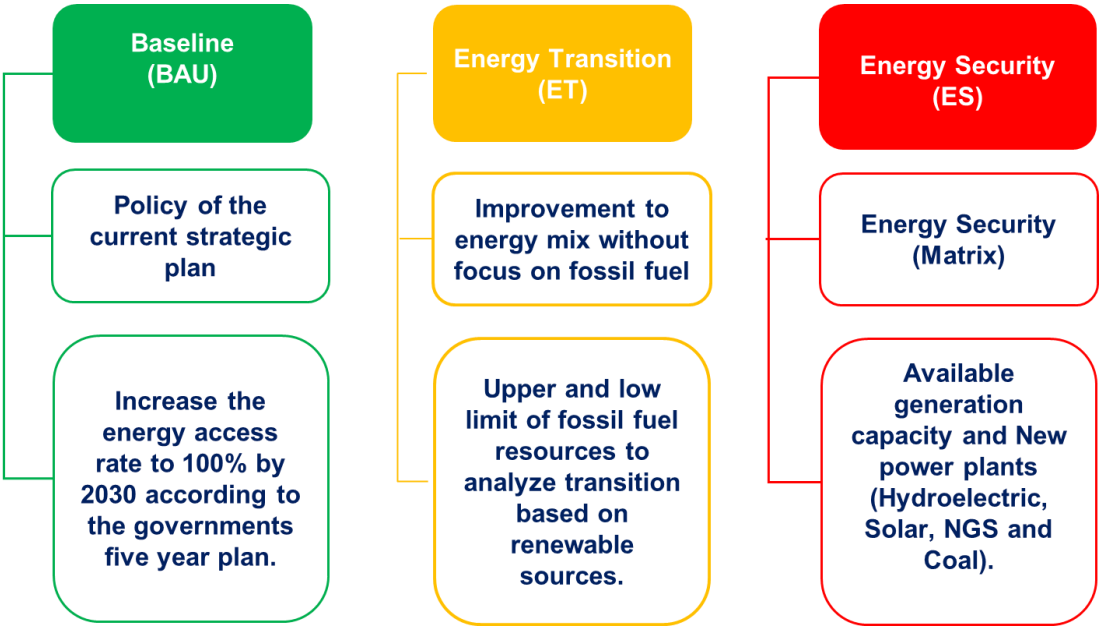

Figure 1. Scenarios

3. Results

In all scenarios, the electricity production capacity was expanded in line with the construction projects for new plants outlined in the priority projects. Notably:

Energy Transition (ET) Scenario: This scenario saw a greater increase in generation plants and stand-alone systems, with the capacity expansion plan extending until the year 2060.

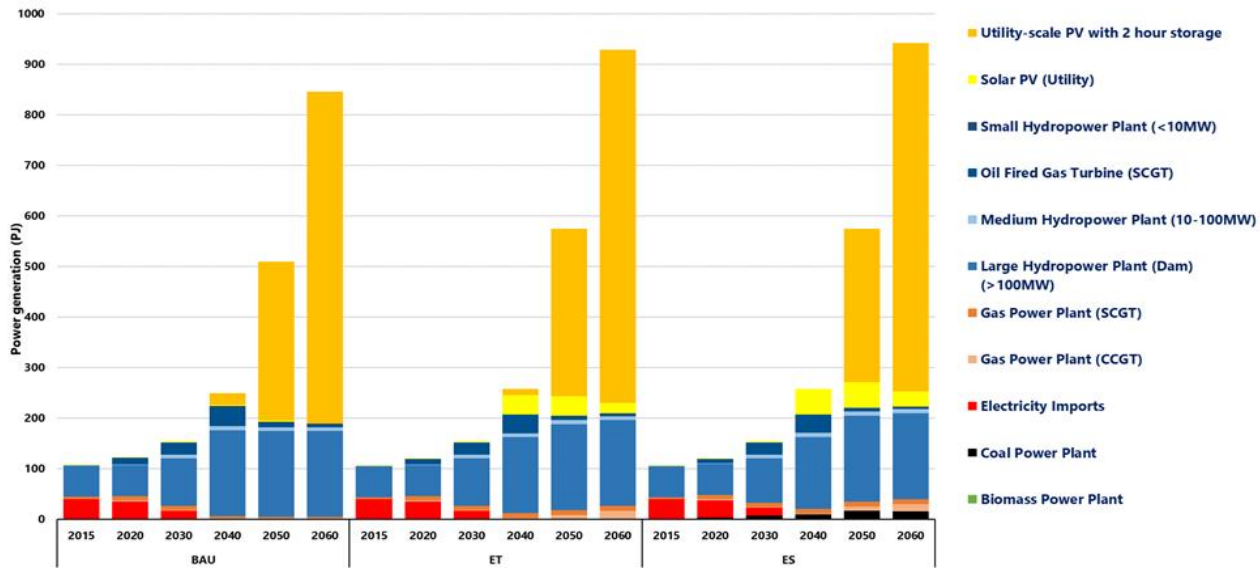

Figure 2. Power Generation

The projections for electricity generation took into account the same assumptions as installed capacity. However, there was an exception made for the specific years of new entries for renewable technologies, which were planned to commence from the year 2040 onwards.

This indicates a strategic focus on integrating renewable energy sources into the generation mix, aligning with long-term sustainability goals and technological advancements.

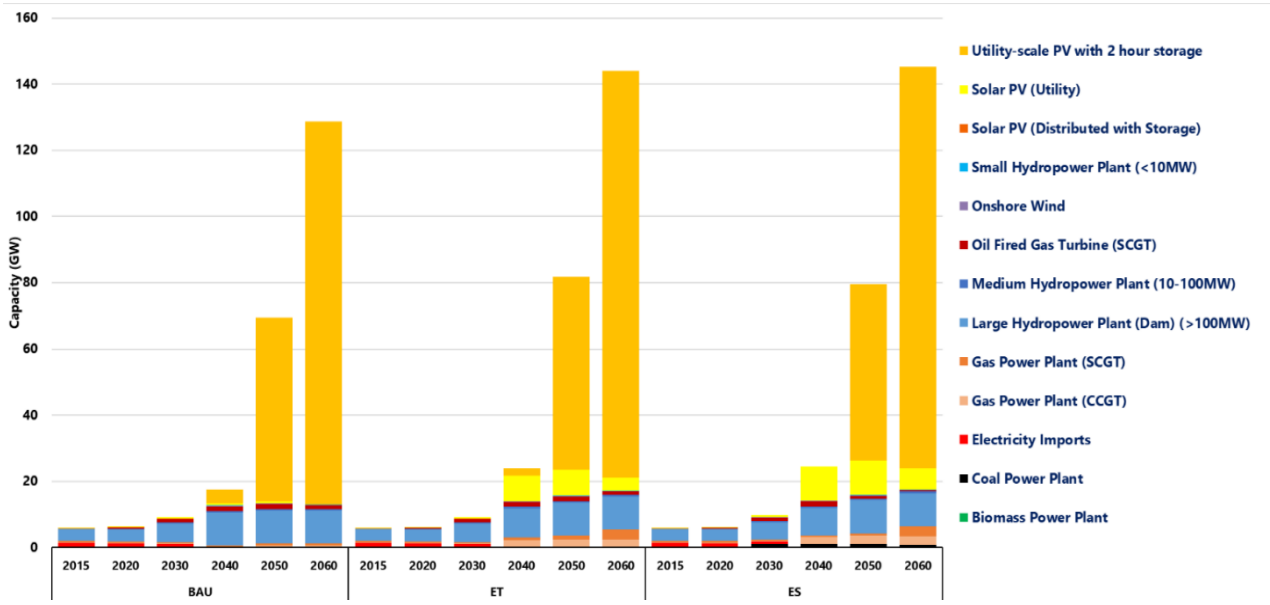

Figure 3. Installed Capacity

The updated total cost includes capital, fixed, and variable costs associated with the evolution of the energy system. The estimated total costs for the BAU, ET, and ES scenarios are as shown in **Figure 4**, and these cost projections encompass the financial aspects of implementing the respective scenarios, reflecting the investments required for infrastructure development, technology deployment, and operational expenses associated with each scenario's energy system evolution.

The Energy Security (ES) scenario necessitates higher investments compared to the BAU scenario, albeit by a relatively small margin, as illustrated in **Figure 4**. However, in economic terms, the significance of the investment in the ES scenario becomes more apparent. This is because the investment value, expressed in Millions of dollars, translates to a difference of approximately **US$3 billion**. Such a substantial amount represents a significant proportion of the investment structure for the country, underscoring the economic weight and implications of pursuing the ES scenario.

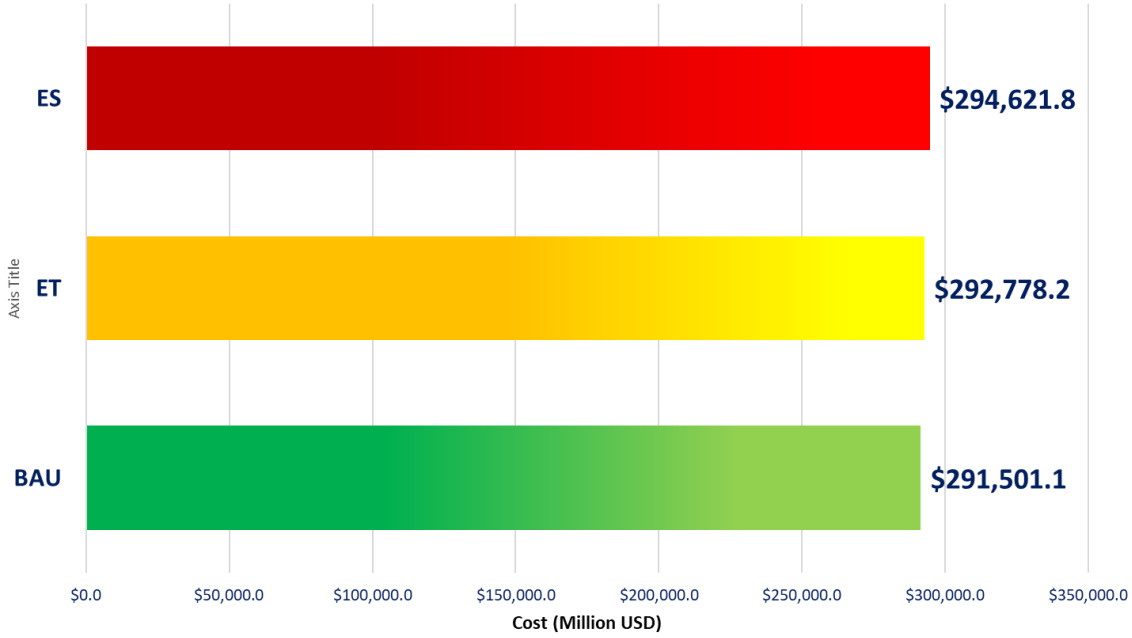

Figure 4. Total Cost

Accordingly with the **Figure 5** Mozambique's contribution to global emissions is small, the country is high vulnerability to climate change necessitates urgent and coordinated action to build resilience and protect its people, infrastructure, and natural resources. By focusing on sustainable development practices and enhancing adaptive capacities, Mozambique can better withstand the impacts of climate change and ensure a more secure and prosperous future for its population.

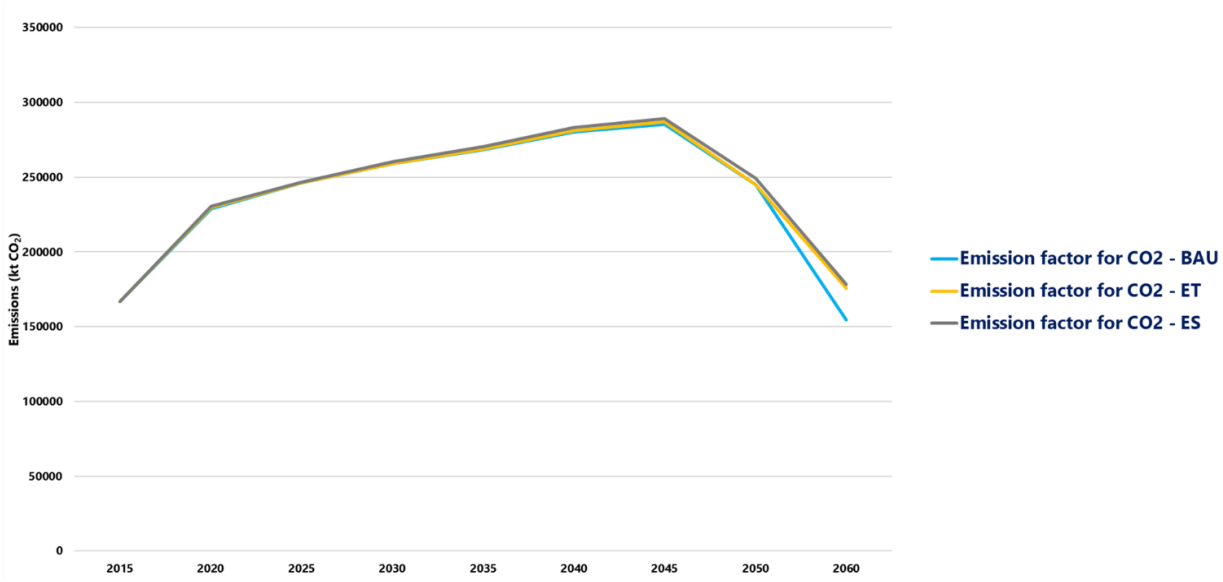

Figure 5. Emission factor

5. Discussion

These three scenarios help in understanding the implications of different energy strategies and in making informed decisions for Mozambique's energy planning;

The **Energy Security** (ES) scenario necessitates higher investments compared to the BAU scenario, albeit by a relatively small margin, which is expressed in Millions of dollars. Therefore this such a substantial amount represents a significant proportion of the

6. Conclusion

Since there are annual and seasonal variations in river flows, the production capacity of the various hydroelectric plants is different, hence the need to combine hydroelectric and thermal renewable plants, in order to guarantee energy balance even in dry periods, which will culminate in reducing dependence on hydroelectric generation by increasing other sources of generation. However, the **Energy Transicon** (ET) focuses on the energy mix with a view to reducing fossil fuels, and the Energy Security Scenario (ES) looks at the energy mix with a view to the country's available energy resources.

The projection criteria considered the country's characteristics and the energy evacuation system. In order to meet the suppressed demand, calibrations were needed looking at the substantial investments in the network over the next few years.

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