

Long Term Energy Plan for Nigeria using Message Code for Energy Optimization

Kabiru Abdullahi
M.Eng Student

Department of Nuclear Power Plant Engineering
KEPCO International Nuclear Graduate School (KINGS)
Ulsan, South Korea

Myung-Sub Roh

Professor of Nuclear Engineering
Department of Nuclear Power Plant engineering
KEPCO International Nuclear Graduate School (KINGS)
Ulsan, South Korea

Abstract - A long term energy plan for Nigeria is a systematic tool designed to provide an informed energy mix scenario that will hugely minimize self-generation trend of electricity and can serve as enabling guide for achieving electrical energy security, using most cost effective and clean energy resources. Energy development profiles, techno-economic data of Nigeria is collected, collated and adopted into the frame work of MESSAGE Code to create a base scenario model of Nigeria energy structure. The base scenario is a close replica of all existing power plants, energy resources, policies and environmental regulations. This scenario forms a reference model for the subsequent prospective scenarios. The study considered a time horizon defined by a base year of 2010 and the limited year at 2031. In this modelling a Back-stop technology was used to overcome infeasibility error that the code generated due to inadequacy of energy infrastructure that can avail the needed energy demand within time horizon of the study. Furthermore, nuclear power energy resource and enforcement of penalty to the technologies with greenhouse gas emission were subsequently introduced. Finally MESSAGE Code provided an optimal energy mix sufficiently enough to feed the country electricity demand.

Keywords- Long-term energy plan; Base Scenario; Prospective Scenarios; MESSAGE Code; time horizon Back-stop technology; Emission penalty.

I. INTRODUCTION

The backbone of human prosperity lies immensely on the ability of humanity to continuously satisfy basic human needs and to sustain advancement in it is quest for civilization. This effort, is shouldered on the ability of a country to explore its energy re/sources efficiently and safely to attain its desired national goals.

Nigeria as in many other countries, encapsulated its energy policies for country's energy development into a National Energy Master Plan (NEMP) to serve as an umbrella policy that gives government an overall energy policy direction drawn from all energy sub-sectoral policies [1]. This paper provides insight on current energy situation in Nigeria. The study further apply the use of analytical code for energy supply and utilization namely; Model for Energy Supply Strategy Alternatives and their General Environmental Impacts (MESSAGE), the code is by design aimed to provide proficient optimized energy scenario that guarantee diverse energy resource option, energy security and efficient delivery system with optimal energy resource mix [2].

Even though, Nigeria has abundance and diverse natural resource reserves, electricity supply is acutely below demand [3], consumption trend is predominantly by self-generation. This paper will introduce the possibility and evaluate implications of deploying Nuclear Power Plant in the Nigeria energy mix using MESSAGE code for informed electrical energy demand forecast, design energy security pathway in most efficient, cost effective and environment friendly approach.

II. METHODS AND RESULTS

A. Methods

The MESSAGE code is designed to develop an optimized model of an energy mix this is achieved by generating matrix and optimization of the generated matrix.

The current energy scenario of Nigeria was modelled to create a case study. This entails coding energy flows: Energy Carries and technologies; demands fluctuations: the load curves; capacities and investment on technologies; Absolute and dynamic limits; Relations and constraints and finally a defined time horizon was adopted with a base year: 2010 and a limited year of 2031. These informations forms part of the input data for simulation in to MESSAGE code.

The base scenario for Nigeria long term energy plan was set at a base year 2010 and extend through 2031. Four scenarios were produced and analyzed.

Base scenario was run to gain insight into circumstances where the current energy structure prevailed. It replicates the Nigeria energy situation and forms a useful background for modeling and analysis of subsequent scenarios. Therefore this base scenario will act as the base standard values or business-as-usual case scenario containing only current existing energy mix.

A scenario with backstop was introduced and analyzed. This was followed by two prospective scenarios: Nuclear Power Plant (NPP) based scenario and a scenario with enforced penalty for greenhouse gas emission. This methodology was adopted and effectively exploited on MESSAGE code which provides for a decisive consideration of the most viable model of energy system that will ensure energy security, sustain economic development and poster a healthy environment.

B. Results

Initially base scenario could not be optimized even though matrix were generated as indicated by the steady line of the graph in figure 1 generated from MESSAGE run. This is because there is no enough energy resource defined in the model that overcome inputted demand. In other words Nigeria installed capacity is inadequate to meet its targeted energy demand.

After introducing backstop technology, MESSAGE, as it can be seen in figure 2 MESSAGE Software was able to optimize the available energy resources defined after introducing backstop technology. Also figure 3 clearly depicted the major energy players in production of electricity based on the consideration of economic viability, available energy resource and healthier environmental impact.

Therefore NPP is introduced in the third model and this cancel the effect of self-generation as shown in figure 4 below. Self-generation makes cost of electricity very expensive and increase environmental pollution.

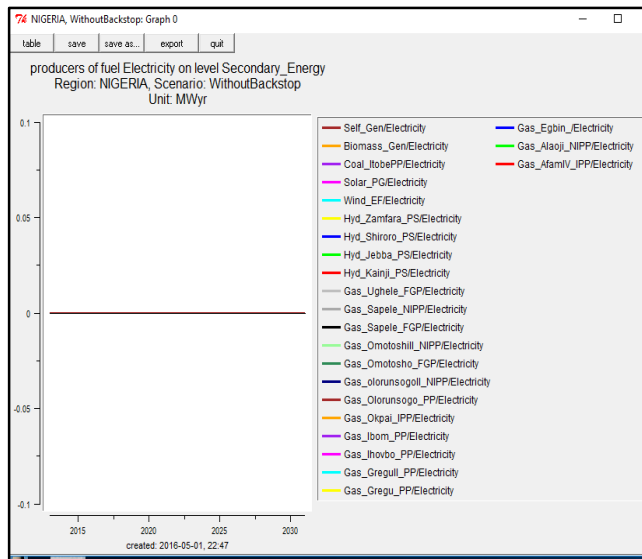


Fig. 1. Result of Base scenario (Steady line)

Second Scenario was based on introducing backstop technology. This is to solve the infeasibility error on MESSAGE code since optimization is not possible without enough energy resources to meet demand.

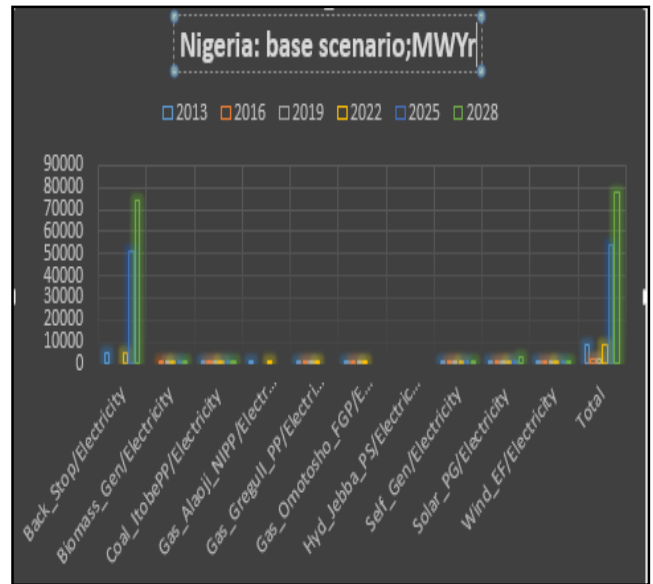


Fig. 2. Result of base scenario with backstop

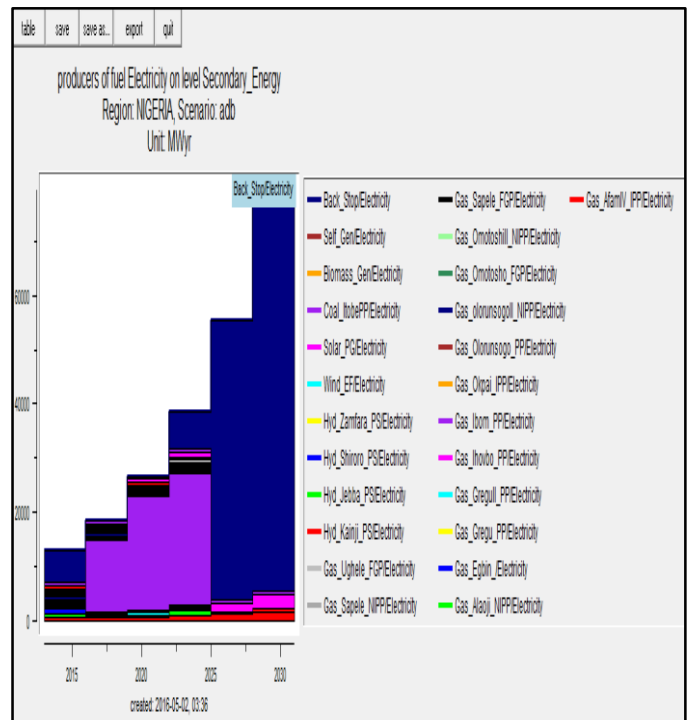


Fig. 3. Producers of electricity

In figure 5, the technologies with the most promised impact in terms of economics and availability are captured and presented in bars with their corresponding tabular values.

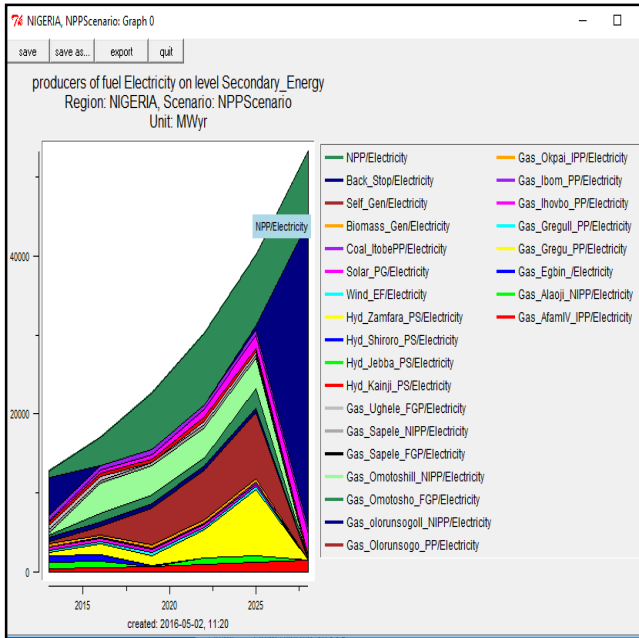


Fig. 4. NPP based scenario

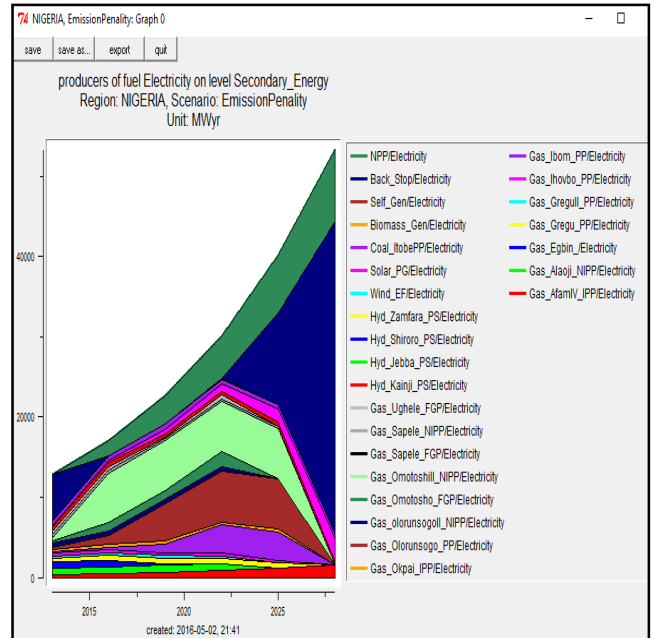


Fig. 6. Emission Penalty

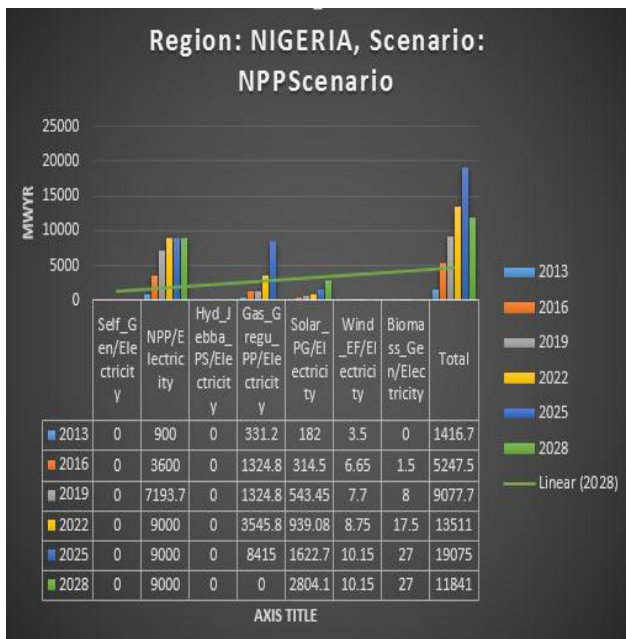


Fig. 5. Major energy players

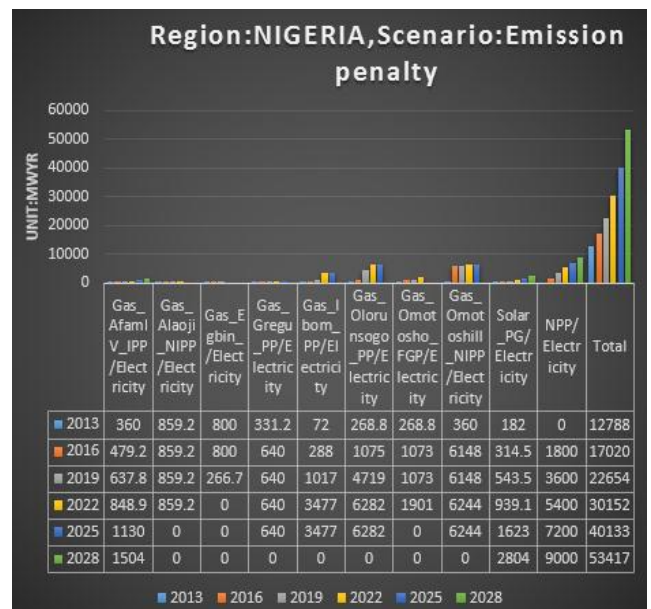


Fig. 7. Result of NPP scenario with penalty

Finally the result of Gas emission introduction indicated further reduction in the contribution of gas power plants and there by pointing out the advantage of NPP above other technologies that produce greenhouse effect as shown in figure 6 and 7.

III. CONCLUSIONS

Nigeria has experienced increased demand dramatically in electricity consumption in the last few years [4]. This rise in consumption requires a corresponding increase in generation capacity and transmission network. The peak demand has also shown an upward trend in the last few years. To mitigate the current energy situation, the government needs to embark on diversification of the country's energy sources to lessen dependence on unsustainable sources like coal, gas and hydropower.

This study has yielded a successful base scenario that takes account of all the existing plants operating in Nigeria and produces a closely real energy situation in the country.

Introducing Nuclear Power Plant into the Nigerian energy Mix appears to overcome the harsh energy scarcity characterised by the country.

It became apparent that a huge reduction of greenhouse emission has been achieved by limiting technologies with harmful environmental emissions using nuclear energy sources which is one of the most cleaner and cost effective energy sources.

The country can also take advantage of available natural resources to strengthen energy production alongside with viable energy sources determined in this studies.

ACKNOWLEDGEMENT

This research was supported by the 2016 Research Fund of KEPCO International Nuclear Graduate School (KINGS), Republic of South Korea.

REFERENCES

- [1] Overview of Nigeria Energy Sector (Professor Eli Jidere Bala, FNSE, FNA Eng, MIAEE Director-General Energy Commission of Nigeria).
- [2] Model for Energy Supply Strategy Alternatives and their General Environmental Impacts, User Manual (International Atomic Energy Agency June 2007).
- [3] The Centre for International Governance Innovation, Nuclear energy Futures Papers: Nigeria and Nuclear Energy: Plans and Prospects (Nuclear Energy Futures Paper No. 11 January 2010).
- [4] Energy implications of vision 2020 and beyond: energy commission of Nigeria (federal ministry of science and technology), federal republic of Nigeria.