Long term energy plan for Nigeria using MESSAGE code for energy optimization

Kabiru Abdullahi, Myung-Sub Roh*
KEPCO International Nuclear Graduate School
658-91 Haemaji-ro Seosaeng-Myeon, Ulju-gun, 689-882 Republic of Korea
**Corresponding author: lokojistic@gmail.com*

1. Introduction

The backbone of human prosperity lies immensely on the ability of humanity to continuously satisfy basic human needs and to sustain advancement civilization development. This effort, 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) , its designed 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.

2. Methods and Results

2.1 Methods

The MESSAGE code is designed to develop an optimization model of an energy system this is achieved by generating matrix and optimization of the model using 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 time horizon is used as input data for adoption 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 (4) scenarios were produced and analyzed.

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

2.2 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 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.

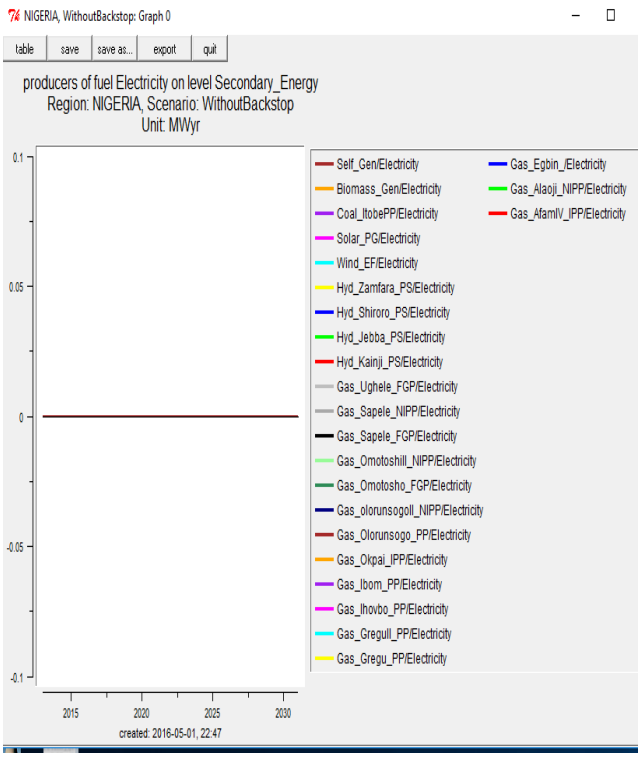


Fig. 1. Result of Base scenario (Steady line)

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

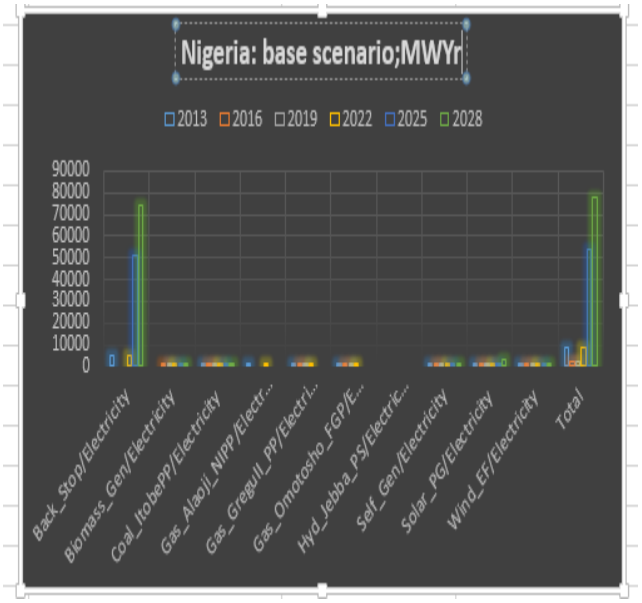


Fig. 2. Result of base scenario with backstop

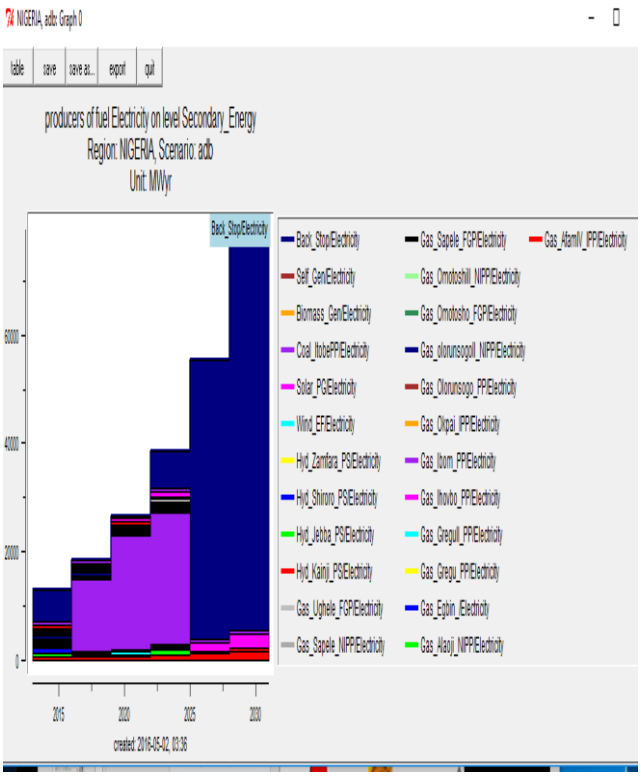


Fig. 3. Producers of electricity

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.

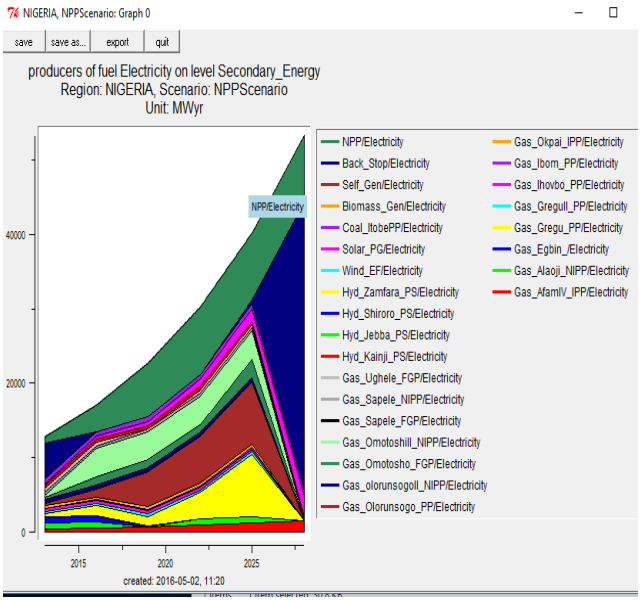
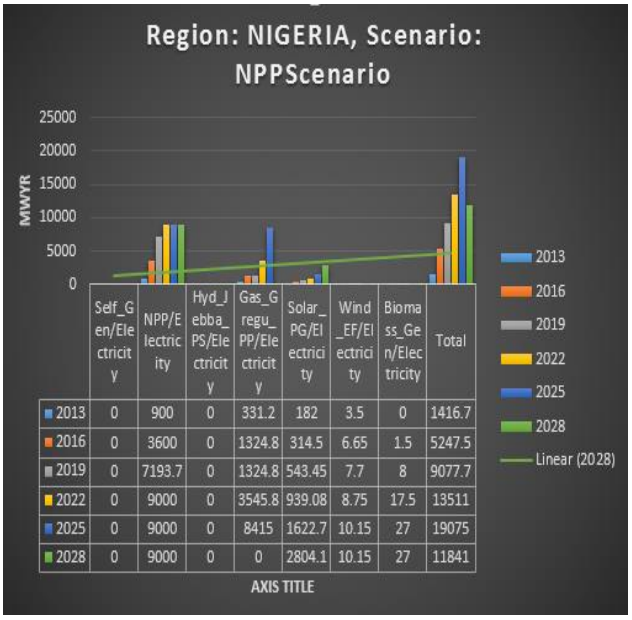


Fig. 4. NPP based scenario



	Self_Gen/Electricity	NPP/Electricity	Hyd_Jebba_PS/Electricity	Gas_Gregu_PP/Electricity	Solar_PG/Electricity	Wind_EF/Electricity	Biomass_Gen/Electricity	Total
2013	0	900	0	331.2	182	3.5	0	1416.7
2016	0	3600	0	1324.8	314.5	6.65	1.5	5247.5
2019	0	7193.7	0	1324.8	543.45	7.7	8	9077.7
2022	0	9000	0	3545.8	939.08	8.75	17.5	13511
2025	0	9000	0	8415	1622.7	10.15	27	19075
2028	0	9000	0	0	2804.1	10.15	27	11841

Fig. 5. Major energy players

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

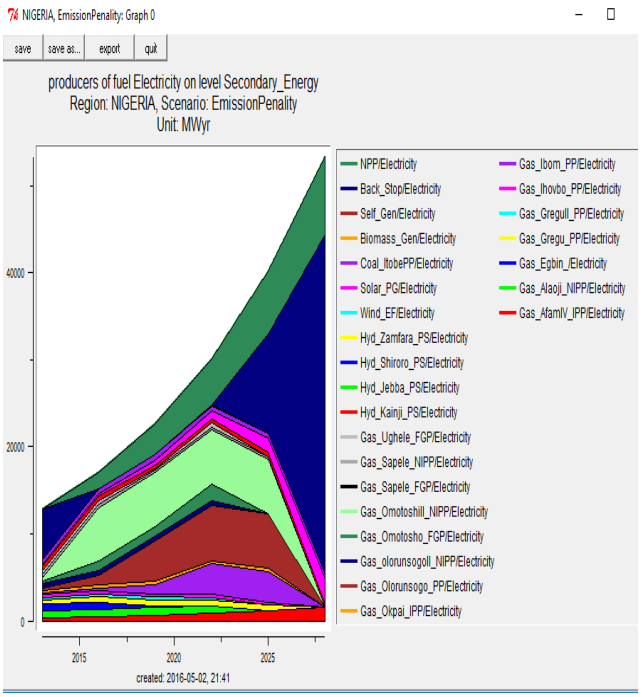
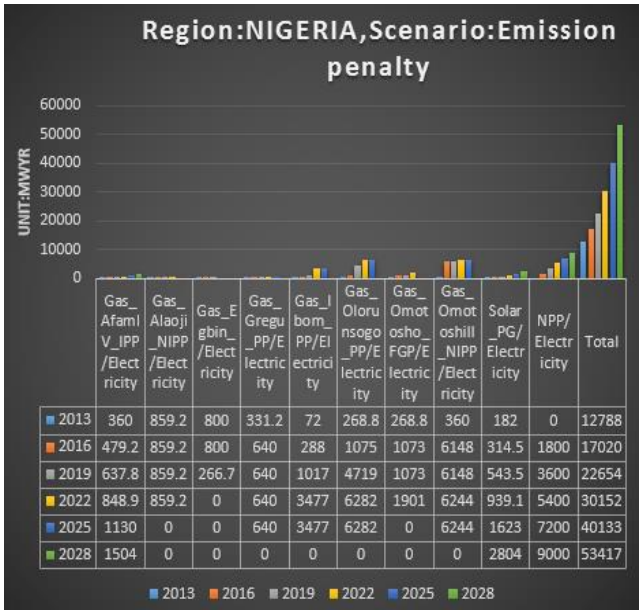


Fig. 6. Emission Penalty



	Gas_AfamIV_IPP/Electricity	Gas_Alaoji_NIPP/Electricity	Gas_Egbin_/Electricity	Gas_Gregu_PP/Electricity	Gas_Ibom_PP/Electricity	Gas_Olorunsogo_PP/Electricity	Gas_Omotosho_FGP/Electricity	Gas_Omotoshill_NIPP/Electricity	Solar_PG/Electricity	NPP/Electricity	Total
2013	360	859.2	800	331.2	72	268.8	268.8	360	182	0	12788
2016	479.2	859.2	800	640	288	1075	1073	6148	314.5	1800	17020
2019	637.8	859.2	266.7	640	1017	4719	1073	6148	543.5	3600	22654
2022	848.9	859.2	0	640	3477	6282	1901	6244	939.1	5400	30152
2025	1130	0	0	640	3477	6282	0	6244	1623	7200	40133
2028	1504	0	0	0	0	0	0	0	2804	9000	53417

Fig. 7. Result of NPP scenario with penalty

3. 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.

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