International Journal of Engineering and Modern Technology (IJEMT) E-ISSN 2504-8848
P-ISSN 2695-2149 Vol 9. No. 3 2023 www.iiardjournals.org

An Evaluation of Nigeria Readiness for net zero emission by 2050

[1]Sule Ihiavi Saliu and [2*]Omejeh Timothy Enejoh.
[1]Department of Mechanical Engineering, Kogi State Polytechnic, Lokoja, Nigeria
[2]Teesside University, Middlesbrough United Kingdom
*oluboh2@gmail.com

DOI: 10.56201/ijemt.v9.no3.2023.pg154.163

Abstract

Due of the detrimental impact that energy consumption and release have on the environment, countries all over the world are currently working to create policies for energy security and climate protection. Additionally, scholars assess ways to reduce Nigeria's energy consumption and greenhouse gas emissions, although little studies have been done on the specifics of these approaches. The Nigeria Energy Calculator 2050 was utilised in this work to assess and contrast the energy balances and greenhouse gas prevention for four potential low-carbon scenarios by the year 2050. The findings demonstrate that while the low-carbon alternatives decreased GHG emissions, they also decreased air pollution. Throughout the analysis we observed that fossil fuel still becomes a major factor in Nigeria energy system in the scenario by 2050. But in order to maintain the nation's transition to a low-carbon economy, greenhouse gas emissions must be prevented. The study's conclusions demonstrate the critical role that energy efficiency and bioenergy play in Nigeria's decarbonisation. An overview of Nigeria's readiness for net zero emissions by 2050 was given by this work.

***Keywords**: Green House Emission, Air pollution, Zero Emission 2050*

INTRODUCTION

The idea of minimal carbon output denotes to an economy which depends on low carbon energy sources and has insignificant GHG discharge output however making sure economic growth simultaneously. This development became prevalent as most improved countries discovered that the abuse of the earth resources portends great danger to earth future (LCS-RNet, 2009).

Energy system models consist of equipment used in determining emerging energy systems with the notion of notifying minimal carbon output plans. The Energy system models can be generally categorized into two, namely, a. The Engineering bottom-up models and b. Macro-economic top-down models (Messner, 1997).

Bottom-up models are used in analysis future energy demands which are detailed illustration of engineering. However, they do not make use of economic effects of energy/climate procedures.

Bottom-up models can be categorized more into: Simulation (e.g: LEAP and MAED); Optimization (e.g: MARKAL/TIMES and MESSAGE); and multi-agent models (Neshat, 2014). Moreover, the top-down models signify the cumulative economy which is used to estimate the cumulative impacts of energy/climate strategies in relations of monetary value; meanwhile they don't denotes detailed technologies.

Energy is crucial for both a nation's safety and socioeconomic development (Casillas and Kammen, 2010). The need for energy has grown due to a protracted increase in population, industrialization, and transportation. Moreover, fossil fuels—coal, oil, and natural gas—produce around 75% of the world's energy. Fossil fuel combustion is a major contributor to global warming and climate change because it releases greenhouse gases (GHGs) into the atmosphere during the production of power, transportation, industrialization, and other economic activities. However, this is the reason why energy utilization arrangement is given special consideration in addressing climate change. The demerits of global climate change can be seen in the shrinking of glaciers, breaking up of lakes and river rice and heat waves among others (Nasa, 2018).

In Nigeria, the effects of climate change are obvious. Examples consist of the shrinking of Lake Chad from about 45,000-3000km^2 between 1960 and 2007 (FGN, 2017) as well as the 2012 flood whose destruction extends to about 1.4% loss of the GDP (US $ 17 billion) in that year (FGN, 2017). As a result of the significance of energy development in addition to the overwhelming effects of climate change, nations across the globe are now thinking of developing models that provide long-term energy security which helps to protect climate change.

In December 2015, the 21st edition of the United Nations Framework Convention on Climate Change (UNFCCC) Conference of Parties (COP-21) was held in Paris. In the conference, Nations all over the word agreed to minimise the effects of global average temperature below 2^0c which is above the level as at the time of the pre-industrial era. Although the Paris Accord was binding for all the countries, attaining this height needs focus transformation in all sectors of the economy, particularly the energy sector which is a major source of GHG emissions globally (FGN, 2017).

Nigeria has shown obligation towards the global efforts in tackling climate change and joined UNFCCC in 1994 and authorized its Kyoto in 2004, and a signatory to the Paris Accord. The country applied for its first and second National Communications to the UNFCCC in 2003 and 2014 respectively, and has hosted several Clean Development Mechanism (CDM) projects (Nasa, 2018)..

Moreover, Nigeria’s energy drive is mainly controlled by traditional biomass and fossil fuels which happens to be the main source of GHG emission in the country. About 50% of the populace depends on traditional fuels for cooking and 60% of the villagers do not have access to electricity (Nbs, 2018). The per capital energy in Nigeria was 763kg of oil equivalent (kgoe) in 2014, which was about 40% of the world’s average of 1919 kgoe. However, the human development index (HDI) as of 2015 was low at 0.527 and ranked globally 152 out of 188 countries (UNDP, 2018). Nigeria has a fast growing population of over 200 million people showing the need for development as a major concern for the country. Absolutely Nigeria energy drive will continually increase as a result of population increase and the desire for socio-economic development.

Sustaining unmet energy demand by safeguarding swift economic development devoid of distorting environment sustainability makes a case for decision makers.

The Nigerian government have goals in pursuing sustainable development and the need to reduce the national GHG emissions. Moderating GHG in Nigeria requires government policies and also citizen will; the use of new technologies as well as populace behaviour will go a long way in solving some of this problems. Infrastructural changes contribute to future challenges in relative to energy demand and GHG

emissions. The year 2050 has been projected as a milestone in the low carbon transition agenda by the Intergovernmental Panel on Climate Change (IPCC). However, between 2050-2100 a negative GHG emission will be needed to keep the global temperature down to 2^0c (Climact, 2018).
Thus, discovering energy paths to 2050 for Nigeria will assist in understanding the drawbacks facing the country in the areas of energy policies and climate mitigation. In this study, we evaluate and compare three situations for low carbon development in Nigeria. In order to achieve the objectives the Nigeria Energy Calculator 2050 (NECAL2050) was used to simulate the energy demand and supply, GHG emissions, Air pollutants likewise policy implications of different scenarios. The final energy demand with house sector of Nigeria as a major energy consumption sector was evaluated. This study is believed to contribute to knowledge of low carbon policies that will be beneficial to Nigeria environment.

METHODOLOGY

NECAL 2050 model was used to achieve a compressive evaluation of energy balances and GHG mitigation capabilities for varying low carbon scenarios. The model was primarily developed by the United Kingdom (Decc, 2018), thereafter other nations across the world joined. The document of various national calculators can be found (2050calculator, 2018). NECAL2050 was established through an MOU (memorandum of understanding) which was signed between United Kingdom and Climate Change (UK-DECC) and the Energy Commission of Nigeria (ECN) in November 2013 which takes place at the British High Commission in Abuja, Nigeria. The ECN is a Nigeria government agency that is responsible for strategic planning and coordination of all the country energy plans.

The model was released in the year 2015 and built on the modelling framework of the UK 2050 pathways calculator. NECAL2050 is a transparent basis of model energy, GHG emissions (CO2, CH4, N2O, HFCs, PFCs, SF6), as well as land use.

The model interpretation for air pollutant emissions such as PM10, NOx, SO2, and NMVOC was evaluated. Two forms of the model were used which include MS Excel-based type as well as the web-based type. NECAL2050 makes use of accounting context algorithm to continually match energy supply to demand. However, it makes use of existing and future technologies in ensuring that the energy supply satisfies the changing demand.

The excel procedure used in this research stabilizes energy demand with supply intervals of three years up to 2050. It is a cohesive model used to identify secured paths for energy supply and demand at low GHG emissions level from 2020 to 2050.

The demand side of the model is divided into four sectors namely a. commercial b. industry c. residential and d. transport sector. These four choices were used by the research to determine the energy supply and then compared the demand-supply figures based on the user choices.

The major energy supply comprises of coal, gas and oil and if the supply is more than the demand, it is presumed that the energy resources are adequate to match the demand. Moreover the model depends on imported petroleum products when domestic energy resources are inadequate to match the demand.

The above mentioned methodology can be mathematically summarized as follows:

Definition:

d_i = sum of sectorial energy demand in year i ……………………………….1

S_i = sum of energy supplies by energy form in year i ………………………….2

Supply minus losses is:

$x_i = s_i - l_i$ ……………………………………………………………………….3

Where x_i represents the supply losses and l_i the sum of energy conversion and distribution losses as well as energy use by energy processes in year i

Then:

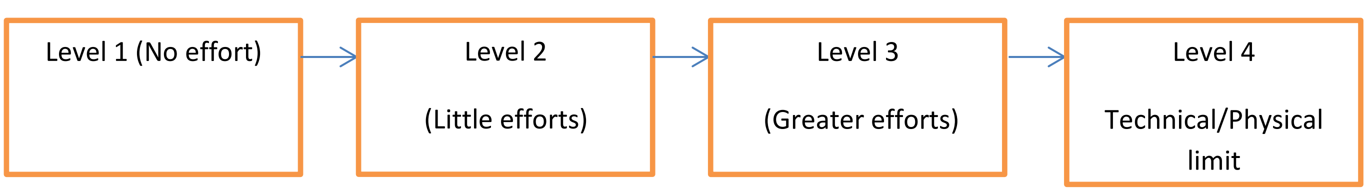
$b_i = d_i - x_i$ ……………………………………………………………………….4

bi is the energy as well as demand difference which is balanced by import or by self-generation.

However there are doubts which are noted in the calculator model. The GHG emission sources in NECAL2050 are categorized into Gas flaring, industrial and transportation from fuel combustion. An in depth analysis of the procedures in reducing emissions from the main sources can be accomplished using NECAL2050. Moreover the varying trajectories explaining the potential change that takes place in the sector in the future is shown.

From the supply view, the route explains the scale of energy production services while the demand route explains the technological variation that might takes place to 2050. These trajectories are shown in various levels in Figure 1. Level 1 shows no effort, Level 2 shows little efforts, Level 3 shows greater effort while Level 4 shows technical potentials/technical limit.

Level 1 advocate no effort towards low carbon supply with already existing infrastructures till 2050, Level 2 shows little efforts towards carbon supply with already existing infrastructures till 2050, Level 3 shows greater efforts towards decarbonization supply with already existing infrastructures till 2050 while Level 4 shows technical potential/ physical limit towards 2050



The macroeconomic likewise demographic assumptions applied in the model of NECAL2050 are shown in Table 2.1. Nigeria GDP is estimated to grow at annual rate of 7% from 286 billion naira in 2010 to around 4450 billion naira by 2050. The expectations for the GDP projection depends on the 7.09% average GDP growth rate noticed between 2007-2011. However, the previous study evaluated by the ECN for energy demand and supply strategies in the nation used 7% GDP growth rate per annum for the reference scenario (IAEA, 2008).

Nigeria population is estimated to increase at a rate of 2.75% from 159 million in 2010 to about 400 million by 2050; however the estimated household is expected to increase from 30 million in 2010 to 80 million in 2050, as computed from the National Bureau of Statistics (NBS) 2010 Annual Abstract of Statistics Report(ECN, 2014)

The aim for choosing the NECAL2050 model for this research is because it was developed locally.

Nigeria- specific data as well as the nation condition on economic and technical route were employed in developing the model trajectories. The model was used due to immense literature and interactions with over two hundred locals so as to ensure the precise assumption on data use of high quality. The model encompasses all the equations, assumptions, and interconnections of variables used in creating the integrated assessment model. Thus, all of the scenarios and analysis presented here are replicable (Michael etal., 2019).

TABLE 1

Macroeconomic and demographic assumptions of NECAL2050.Source: (ECN, 2015).

Year	GDP (billion NGN)	Annual GDP growth rate (%)	GDP per capita (NGN)	Population (million persons)	Household size	Number of households (million)
		6.34	1,975.34	159	5.2	30
2010	286.28	6.85	3,010.90	207	5.4	38
2020	551.43	7.25	4,681.31	265	5.0	53
2030	1097.47	7.25	7,363.80	331	5.0	66
2040	2209.86	7.00	12,163.91	403	5.0	80
2050	4449.78					

.

The levels selected for each scenario are shown in Table 2.

TABLE 2

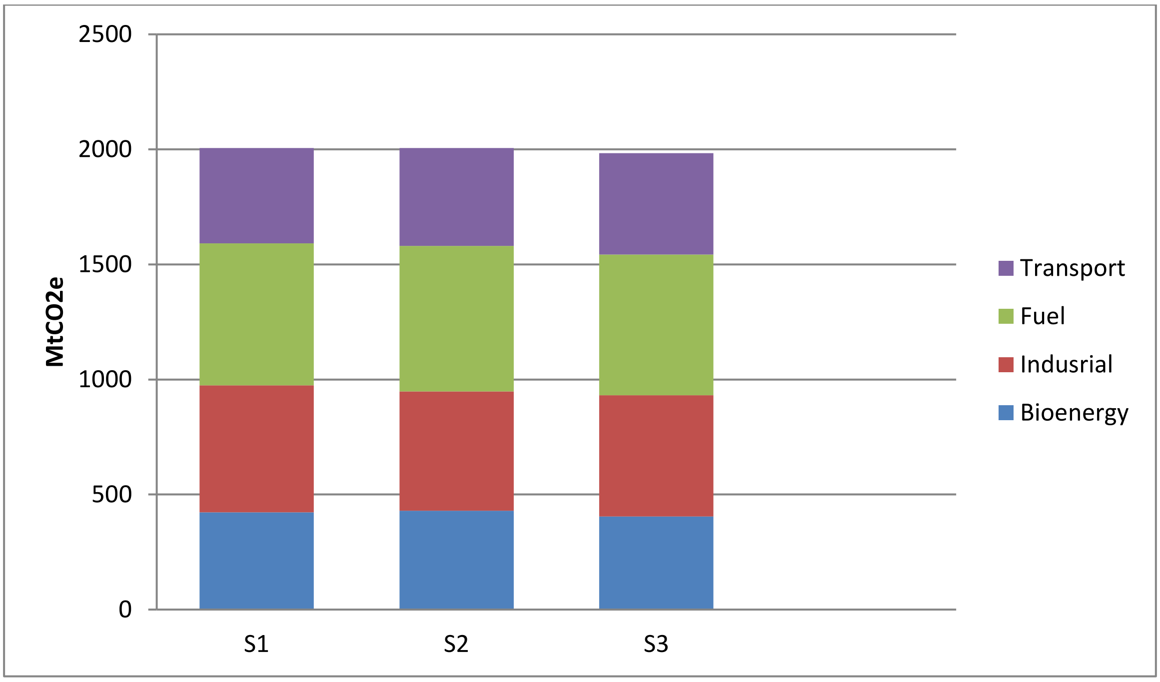
Levels selected for each scenario.

Sectors	Levers	Levels selected for each scenario			
		S1	S2	S3	
Bioenergy supply	Agriculture and land use Land dedicated to bioenergy	1	1	1	
			1	3	2
	Livestock and their management			1	1
	Volume of waste and recycling		1		1
	Type of fuels from biomass		1	4	
	Bioenergy imports		1	3	2
				1	3
			2		1
	Domestic passenger transport		3	2	
	Domestic transport behavior		1	3	3
				1	3
D	Shift to low carbon emission transport technology		2		1
e	Fuel switch for internal combustion engine Domestic		3	3	
m	freight		1	2	1
a					
n					
d					
T	Residential cooling				
r	Cooling demand	1	2	1	
a			1	2	1
n	Efficiency of cooling system			1	2
s			1		1
p	Residential lighting, appliances, and cooking		3	1	
o	Residential lighting, appliances & cooking		1	2	1
r	Technology pathway (cooking)				
t					
	Industrial processes				
	Growth in industry with GDP	1	2	1	
	Energy intensity of industry		1	4	3
				1	4
Households			1		1
			2	1	
	Service sector cooling				
	Service sector demand for cooling	1	2	2	
	Efficiency of cooling system				
		1	2	2	
	Service sector lighting, appliances, and cooking				
	Service sector lighting, appliances & cooking				
	Technology pathway (cooking)				
Industry					
		1	3	1	
		2	1	2	
		1	2	3	
Services					
		1	4		

RESULTS AND DISCUSSION

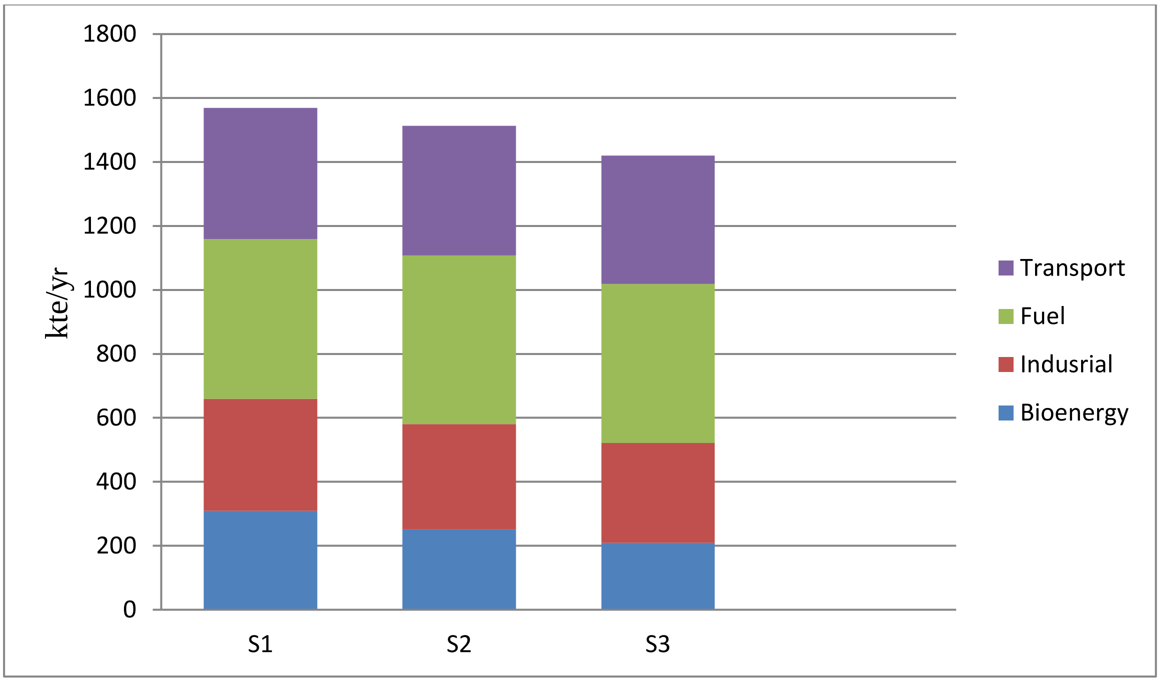
GHG emissions analysis

GHG emissions for three scenarios in 2050 are shown in Figure 3. It was observed that from Senario S1 the highest emissions were fuel consumption while the least emissions was observed in transport. For Senario S2 fuel consumption had the highest value and slightly followed by industrial while the least value was observed in the bioenergy sources. Senario S3 had fuel consumption as the highest and closely followed by industrial while bioenergy resources had the least value. Though carbon capture and storage (CCS) was outlined in the NECAL2050, it has not been considered here since the model developing team didn't consider it as an option for Nigeria by 2050 (Michael etal, 2019).



Air pollution and sensitiveness investigation

Air pollutant results by the year 2050 for the various scenarios are presented in Figure 3.2 which is estimated in kilotons equivalent of air pollutant per year (kte/yr). It can be observed that the air pollutant decreased in the alternative scenarios as compared to the reference. Similar trends are seen for all kinds of air pollutants. It was observed that from Senario S1 the highest emissions were fuel consumption while the least emissions were observed in transport. For Senario S2 fuel consumption had the highest value and slightly followed by transport while the least value was observed in the bioenergy sources. Senario S3 had fuel consumption as the highest and closely followed by transport while bioenergy resources had the least value. The result indicates that with the massive introduction of energy-efficient appliances in the household sector, the sector has the potential to reduce the country's overall energy demand in 2050 by around 25.7% relative to the reference case. Thus, energy efficiency practices should be the key focus of policymakers with respect to the residential sector.



Conclusion

The following conclusions have been drawn

The research explored four alternative minimal carbon development paths for the nation.

Furthermore, the Senarios regarded the minimal carbon approach as a focal point in the nation's broader growth strategy. The Nigerian government suggests setting developmental objectives to reach a sustainable mode. When compared to the reference scenario, the alternative scenarios show lower energy usage, greenhouse gas emissions, and air pollution. Nonetheless, by 2050, fossil fuels would still dominate Nigeria's energy system in every scenario. Consequently efforts are made to decarbonize GHG emissions so as to maintain Nigeria on the accurate path of low carbon route. According to the established analysis, Nigeria's current sustainable energy initiatives would undoubtedly improve air quality and reduce greenhouse gas emissions, helping the country to meaningfully decarbonise by the year 2050.

It is recommended that efforts for minimising carbon emissions concentrate on the primary source of greenhouse gas emissions in Nigeria, which is the combustion of fossil fuels.

The greatest potential for reducing greenhouse gas emissions in the supply and demand sides of the nation's energy system lies in initiatives that link full exploitation with energy efficiency practices. Despite the fact that additional renewable energy sources are strongly advised for the low-carbon transition to support Nigeria's energy system. So, biofuels can be used as substitute as alternative for fossil fuels. In recent times, the Energy Commission of Nigeria (ECN) started a partnership with United Nations Development Programme majorly in industrial and local set-up; all these procedures can shoot Nigeria on the path of low carbon transition.

However, with the limitations, it's known that the results gotten can support policy judgement in respect to minimal carbon transition in Nigeria.

References

2050 calculator | Completed calculators (n.d.). https://www.2050.org.uk/ calculators. (Accessed 9 February 2018).

C.E. Casillas, D.M. Kammen, Science 330 (2010) 1181–1182. , http://dx.doi.org/ 10.1126/science.1197412.

CLIMACT, VITO, Scenarios for a Low Carbon Belgium by 2050, 2013 . (Accessed 8 February 2018)

DECC, The UK 2050 Calculator. Webtool and Supporting Documents, DECC: Department of Energy and Climate Change, London, UK, 2018, . (Accessed 9 February 2018) http://classic.2050.org.uk/pathways/

ECN, Energy Implications of Vision 20: 2020 and Beyond, 2014 . (Accessed 15 October 2017).

ECN, Nigeria Energy Calculator 2050 (NECAL 2050) Report, 2015, p. 105 http:// www.energy.gov.ng/index.php?option=com_docman&task=doc_view&gid=123&Itemid=49. (Accessed 14 October 2017).

FGN, Nigeria Intended Nationally Determined Contribution, 2015, pp. 1–23. (Accessed 6 June,2017)http://www4.unfccc.int/ndcregistry/PublishedDocuments/NigeriaFirst/ApprovedNigeria%27sINDC_271115.pdf.

IAEA/ECN, Assessment of Energy Options and Strategies for Nigeria: Demand, Supply and Environmental Analysis for Sustainable Energy Development (2000– 2030), 2008.

IPCC, Synthesis Report: Contribution of Working Groups I, II and III to the 5th Assessment Report of the Intergovernmental Panel on Climate Change (Core Writing Team, R.K.

LCS-RNet, Achieving a Low Carbon Society: Synthesis Report, Bologna, Italy, 2009 https://lcs-rnet.org/pdf/publications/2009SynthesisReportEN.pdf.

N. Neshat, M.R. Amin-Naseri, F. Danesh, J. Energy South. Afr. 25 (2014) 101–111.

NASA, Climate Change: Vital Signs of the Planet: Effects (n.d.). https://climate.nasa.gov/effects/. (Accessed 8 February 2018).

NBS, LSMS-Integrated Surveys on Agriculture: General Household Survey Panel 2015/ 2016, 2017 . (Accessed 7 July 2017) http://www.nigerianstat.gov.ng/download/388.

Pachauri and L.A. Meyer), Geneva, Switzerland, 2014 ipcc.ch/ pdf/assessment-report/ar5/syr/AR5_SYR_FINAL_All_Topics.pdf.

REN 21, Renewables 2014: Global Status Report, REN21 Secretariat, Paris, 2014.

S. Messner, Endogenized Technological Learning in an Energy Systems Model, Springer Verlag, 1997 . (Accessed 25 May 2017) http://econpapers.repec.org/article/sprjoevec/v_3a7_3ay_3a1997_3ai_3a3_3ap_3a291-313.htm.

UNDP, Human Development for Everyone: Briefing Note for Countries on the 2016 Human Development Report – Nigeria, 2016 . (Accessed 4 May 2018) http://hdr.undp.org/sites/all/themes/hdr_theme/country-notes/NGA.pdf.