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Electricity Demand and Supply Scenario Analysis for Nigeria Using Long Range Energy Alternatives Planning (LEAP)

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Authors' contributions

This work was carried out in collaboration between both authors. Author GK designed the study and facilitated the use of the LEAP software. Author HAI managed the analyses of the study, managed the literature searches and wrote the first draft of the study. Both authors read and approved the final manuscript.

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ABSTRACT

Electricity demand and supply forecasts are important tools for determining solutions to the problems in the electricity sector such as power outages. The Long Range Energy Alternative Planning (LEAP) modelling tool was used to project electricity demand and supply for a target year 2040. Three scenarios namely; Business as Usual (BAU), Energy Conservation (EC) and Renewable Energy (REN) were generated. The three scenarios were analyzed based on electricity demand and supply, environmental impacts and costs. The electricity demand in the target year of 2040 for the BAU and REN scenarios increased to 283.6 billion kWh, while that of the EC scenario increased to 233.8 billion kWh from 35.9 billion kWh in the base year (2010). The EC scenario has the least capital cost (44.2 billion USD less than the BAU scenario) and fixed costs (15 billion USD less than the BAU scenario), the EC scenario also has the second largest quantity of Green House Gas (GHG) emissions (1,004.8 million tons of CO2eq). The REN scenario has the least GHG

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emissions among the three scenarios (114.79 million tons of CO2eq) but is the most expensive scenario to implement because of its high capital (56.3 billion USD more the BAU) and fixed costs (4.1 billion USD more than the BAU scenario). As a result of the economic challenges faced by Nigeria, the EC scenario was found to be the most realistic path in providing uninterrupted power supply.

Keywords: LEAP model; energy conservation; renewable; greenhouse gas emissions; cost analysis; energy modeling.

1. INTRODUCTION

Electricity is essential for the economic development of a country. Electricity consumption per capita is used as a measure to determine how developed a nation is, this clearly shows how important electricity is to the development of any nation. New findings in science and technology, made electricity the most preferred form of energy. Electricity can be easily converted into other forms of energy and has greater flexibility compared to other forms of energy.

Nigeria has a GDP of $486.793 billion dollars and is the 23rd largest economy in the world [1]. According to vision 20:20, Nigeria targets to be among the top 20 largest economies in the world by 2020 but for that to be achieved it will have to eliminate power outages, which has stagnated the development of the industrial and educational sectors. Nigeria's available electrical capacity ranges between 3500MW to 5000 MW [2]. For a population of 186 million people, this capacity is clearly insufficient. The electricity supply mix is only made up of hydro and gas power plants, which have a percentage share of 22.9% and 77.1% respectively.

The Nigerian government has made efforts to improve electricity supply over the years in order to reduce power outages across the nation. Nigeria has allowed the involvement of foreign companies in the power sector to generate their own electricity (IPP-Independent Power Plants) and sell it to distribution companies. Still, the intervention of the private sector has not solved the recurrent power blackouts experienced all over the country. This has not only underdeveloped the nation but caused national embarrassment as in the case of the blackout at the Murtala Mohammed International Airport in Lagos and the 2009 FIFA under 17-world cup. Increase in population and a rapid economic growth, the government needs to make policies based on forecasts of electricity demand and supply to ensure that power outages are eradicated and there is constant electricity supply in Nigeria.

The Long Range Energy Alternatives Planning (LEAP) energy model was developed by the Stockholm Environment Institute to analyse energy policies and to assess GHG emissions [3]. A major advantage of LEAP is its low data requirements and is based on physical energy and ecological policies. LEAP has been used by individual researchers and organisations to project future energy supplies, consumptions and GHG emissions to enable them to formulate energy policies. Various studies were carried out on energy demand and supply forecasts, different scenarios were generated and compared to each other on the basis of GHG emissions and costs. [4] generated three scenarios for Korea using LEAP and analysed the energy, environmental and economic impacts. The paper highlighted how important the sustainable scenario is. [5] carried out demand and supply analysis for Iran using LEAP. [6] analysed the electricity demand and supply in Maharashtra (India). The paper found out that the renewable energy scenario is superior to the other scenarios in many aspects. Other studies in projecting future electricity generation mix using LEAP were carried out by [7] and [8].

Decisions on how to eradicate electricity outages can be made based electricity demand and supply forecasts. This paper used LEAP to project the electricity demand and supply from 2010 to 2040. The three scenarios were compared to each other on the basis of electricity demand and supply, GHG emissions and costs.

2. METHODOLOGY AND DATA

2.1 The LEAP Model

We have used LEAP to calculate energy supply as a result of transformation from available fuels by means of power plants and energy demand as a result of final energy consumption. LEAP balances energy supply and demand at each time step and calculates emissions and costs accordingly. The framework used by LEAP for the calculation of energy consumption and carbon emissions as according to [9] is presented as follows:

2.1.1 Energy consumption

The total final energy consumed is calculated using equation 1:

$$EC_n = \sum_i \sum_j AL_{n,j,i} \times EI_{n,j,i} \tag{1}$$

EC is the aggregate energy for a given sector, *AL* represents activity level, *EI* is the energy intensity, *n* is fuel type, *i* is sector, and *j* is the device.

Transformation of net energy consumption is calculated using equation 2:

$$ET_s = \sum_m \sum_t ETP_{t,m} \times \left(\frac{1}{f_{t,m,s}} - 1 \right) \tag{2}$$

ET is the transformation net energy consumption, ETP being the net energy transformation product, f is the energy transformation efficiency, s is the type of primary energy, m is equipment, and t the type of secondary energy.

2.1.2 Carbon emission

Carbon emission of the final energy is calculated using equation 3:

$$CEC = \sum_i \sum_j \sum_n AL_{n,j,i} \times EI_{n,j,i} \times EF_{n,j,i} \tag{3}$$

Whereby *CEC* stands for carbon emission, *AL* is activity level, *EI* is energy intensity, $EF_{n,j,i}$ is carbon emission factor, *n* is for equipment *j* from sector *i*

Then the carbon emission of energy transformation is obtained using equation 4:

$$CET = \sum_s \sum_m \sum_t ETP \times \frac{1}{f_{t,m,s}} \times EF_{t,m,s} \tag{4}$$

CET is the carbon emission, *ETP* energy transformation project, *f* is energy transformation efficiency, $EF_{t,m,s}$ is emission factor from primary fuel type *s* for producing fuel type *j* through equipment *m.*

2.1.3 Costs

Costs are calculated using the following equation 5, [10]:

$$C = \sum_i \sum_j \left\{ \left[\sum_n (e_{n,j,k} \times ep_n) + \sum_k (m_{k,j,i} \times mp_k + fc_{j,i}) \right] P_{i,j} \right\} \tag{5}$$

C is the total cost, ep_n is unit price of fuel type n, $m_{k,j,i}$ is demand for material k per unit of production used in equipment j within production process I, mp_k unit of material k and $fc_{j,i}$ fixed cost per unit production through equipment j. $P_{j,i}$ is the production output (in process i) through equipment j. $e_{n,j,k}$ is the energy consumption of fuel type n used in equipment j (within process k).

2.2 Scenario Development

2.2.1 Structure of the Nigerian LEAP model

The Nigerian LEAP tree diagram is made up of two branches namely the demand and supply branch. The demand branch is made up of the household sector which is divided into urban and rural, with final energy end users such as electricity, refrigeration, air conditioning, electronics, food preservation, and water heating. The demand branch also includes the commercial and industrial sector. The supply branch is made up of existing power generation plants such as hydro and nuclear, with power plants that are going to be introduced in future like nuclear, small hydro, biomass, wind, and small hydro.

2.2.2 Scenarios used for the analysis

Scenarios describe how the energy system will evolve in the future under various conditions. In this study, three scenarios namely; Business as Usual (BAU), Energy Conservation (EC) and Renewable Energy were generated.

2.2.2.1 Business as Usual Scenario (BAU)

The BAU scenario was developed based on the path that electricity demand and supply polices will continue in the future in the same way they were in the past. All the variables and parameters are assumed to follow the past trend. This includes efficiencies, generation technologies as well as transmission and distribution losses.

In the BAU scenario, demographic and economic data used consists of a population growth at 2.55 percent, income growth at 8.6%, share of the urban population at 50% by 2040. Electricity access in the urban areas will increase to 90% by 2030 from 79.8% while that in the rural areas will attain 60% in 2030 from 34.9 percent. In the BAU scenario, there would be the addition of nuclear power plants with a capacity of 1200 MW by 2025, two 1000MW and 500 MW coal power plants will be introduced in 2014 and 2015 respectively. The current hydro and gas power plants will be expanded to a capacity of 13000 MW and 9000 MW by 2040 respectively. Transmission and distribution losses will remain at 17%.

2.2.2.2 Energy Conservation Scenario (EC)

Energy conservation is very important because energy consumption and the need for power generation expansion are significantly reduced. The EC scenario was formulated from policy documents such as National Renewable Energy and Energy Efficiency Policy (NREEP, 2015), Sustainable Energy for All Action Agenda (SE4ALL-AA, 2016), and The Renewable Energy Master Plan (REMP, 2013). This scenario shows us how electricity demand and supply will evolve in the future if energy efficiency measures as stipulated by the documents mentioned above are implemented. The following information was used to develop the EC scenario:

- Efficient lighting will attain 40% by 2020 and 100% by 2040.
- The efficiency of energy intensive technologies will reach to 20% by 2020 and to 50% by 2030.
- Transmission and distribution losses will be reduced from 17% in 2010 to below 10% by 2030 (8% is chosen).

2.2.2.3 Renewable Energy Scenario (REN)

Nigeria has abundant renewable energy resources such as solar, wind, hydro, and biomass. Therefore, taking advantage of these available resources for electricity generation is a priority for the Nigerian government in terms of energy security and reduction in GHG emissions.

The REN scenario is made up of an introduction of renewable power plants and no new gas power plants in future. NREEP and REMP were used in developing scenarios with the following technologies listed below:

- Hydropower plants will attain 9000 MW by 2040.
- Small hydropower plants will grow to 8173.81 MW by 2030.
- Solar PV will attain 6831 MW by 2030.
- Introduction of 1200 MW nuclear power plant in 2025.
- Biomass will attain 292 MW by 2030.
- Wind will attain 3211 MW by 2030.

2.3 Data

The data that used for this study was obtained from various sources as given in Table 1.

3. RESULTS AND DISCUSSION

3.1 Electricity Demand Projections

The electricity demand of the three scenarios was projected from the base year of 2010 to the target year 2040. Electricity demand for the three scenarios has continuously increased until 2040. This is attributed to increase in population, urbanization, income growth rate and increase in GDP. Electricity demand in the BAU and REN scenarios increased from 35.9 billion kWh in 2010 to 283.6 billion kWh by 2040 as shown in Fig. 1 on the other hand, electricity demand in EC scenario increased from 35.9 billion kWh in 2010 to 233.8 billion kWh as given in Fig. 2. From the electricity demand in the BAU and REN scenarios, we see that urban households have the highest share of electricity demand in the base year 2010, with a total electricity demand of 17.4 billion kWh while rural constitutes 9.9 billion kWh (Fig. 1). The majority of the electricity demand in the urban households comes from lighting.

Other high electricity demand sectors are refrigeration (4.5 billion kWh), rural lighting (3.7 billion kWh) and rural refrigeration (2.5 billion kWh). Electricity consumption in the commercial and industrial sectors are 5.5 billion kWh and 3.2 billion kWh respectively. The electricity demand increased to 283.6 billion kWh in 2040, with the urban electricity demand constituting 75.3 billion kWh, lighting constituting 28.3 billion kWh. Demand for lighting in the rural areas increased to 9.7 billion kWh as well. Electricity demand in industrial and commercial sectors massively increased to 18.6 billion kWh and 163.4 billion kWh, respectively.

The demand for electricity in the EC scenario considerably reduced because of the energy efficiency measures are taken as well as the reduction of transmission and distribution losses. By 2040, the electricity demand for the EC is 233.8 billion kWh which is a 49.8 billion kWh saving compared to BAU or REN scenarios. The urban household electricity demand is reduced to 59.3 billion kWh under the EC scenario, electricity demand of the rural areas is 28.9 billion kWh, the industry is 14.9 billion kWh, and commercial is 130.7 billion kWh.

Table 1. Data used for the study

Data	Source
GDP, GDP per capita, Income growth rate, Population, Population growth rate, Urban and Rural population/percent, Industry and commercial value added	The World Bank Development Indicators [11]
Energy intensities of electrical appliances	Sustainable Strategies for Low Carbon Development in Nigeria [12], Characterization of the household electricity consumption in the EU, potential energy savings and specific policy recommendations [13].
Government renewable energy and energy efficiency plan	Sustainable Energy for All Action Agenda (2016) [14] The Renewable Energy Master Plan (2013) [15]. National Renewable Energy and Energy Efficiency Policy (2015) [16].
Emission factors	IPCC guidelines for national GHG inventories [17].
Electricity sector characteristics (generation, transmission, capacity factor, historical production)	National Control Center Osogbo Generation and Transmission Grid Operation Annual Technical Report (2010) [18].

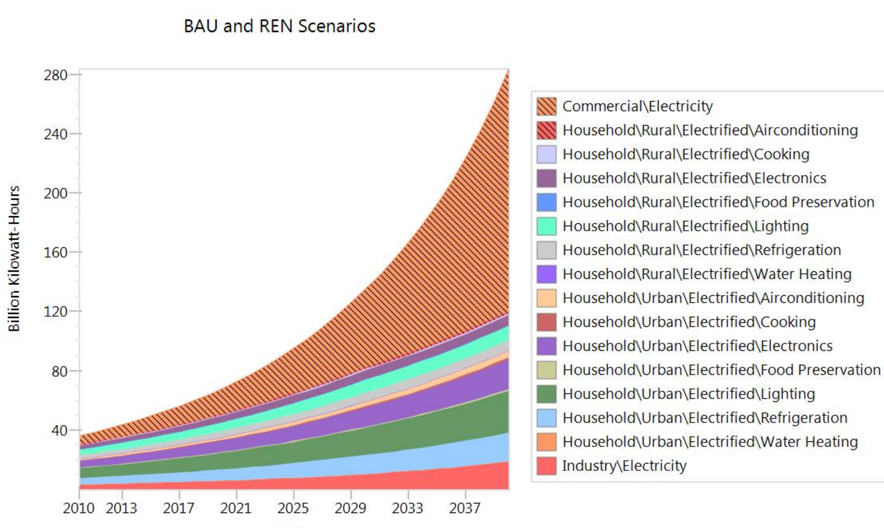

Fig. 1. BAU and REN electricity demand projection

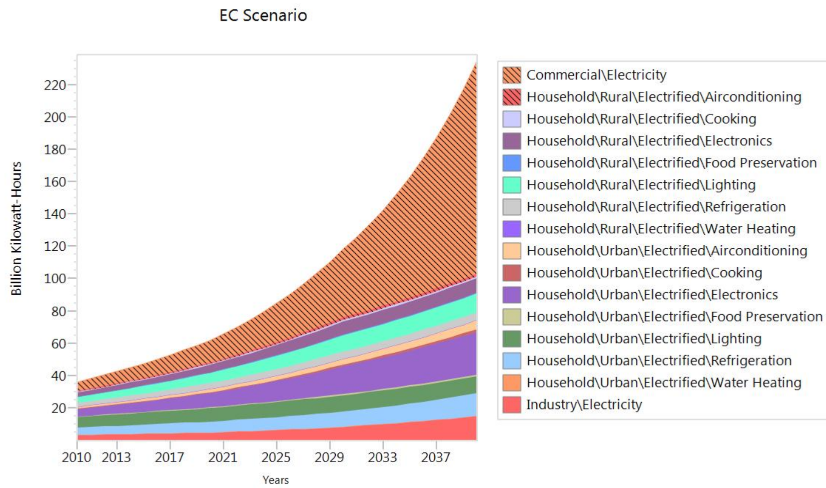

Fig. 2. EC Electricity demand projection

3.2 Electricity Supply Projections

The electricity supply in the base year stands at 23.8 billion kWh which do not meet the required electricity demand in the base year. This shortage is the reason behind power outages in Nigeria. But with the introduction of new power plants and expansion of the existing ones as formulated in the BAU, EC and REN scenario the electricity supply will match the electricity demand as highlighted in the coming sections.

Electricity supply in 2010 for the BAU scenario is 23.8 billion kWh, in which natural gas power plants supplied 17.4 billion kWh and hydropower plants supplied 6.4 billion kWh. Electricity supply in the BAU scenario increased from 23.8 billion kWh to 341.7 billion in 2040 as shown in Fig. 3.

Electricity supply in the REN scenario increased from 23.8 billion kWh to 336.1 billion in 2040 as given in Fig. 4. The electricity supply mix contained technologies such as small hydropower plants, biomass power plants, solar PV, nuclear power plants, wind power plants, hydropower plants. The capacity of the natural gas power plants was not increased in the REN scenario.

Electricity supply for the EC scenario attained 254.1 billion kWh in 2040 as given in Fig. 5. This clearly shows a massive reduction in electricity supply of 87.6 billion kWh in 2040 when compared to the BAU scenario and a reduction of 82 billion kWh 2040 when compared to the REN scenario.

3.3 GHG Emission Analysis

The Greenhouse Gas (GHG) emissions of the BAU, EC, and REN scenarios for the study carried out are given Fig. 6. GHG emissions are measured in million metric tonnes of carbon dioxide (CO_2) equivalent. GHG emissions from the power generating plants in the BAU scenario increased from 6 million metric tons of CO_2eq to 123.9 million metric tons of CO_2eq. Carbon dioxide takes the major chunk of the GHG but there are other gasses such as methane and nitrous oxide. The rapid increment in the GHG for the BAU is due to the addition of coal power plants and expansion of the capacity of the gas power plants. The 1000 MW and 500 MW coal power plants emit the largest quantities of GHG emissions with 82.1 million metric tons of CO_2eq and 41.1 million metric tons of CO_2eq respectively. The natural gas power plant has the least emission when compared to the coal power plants being 0.7 million metric tons of CO_2eq because natural gas has less GHG emissions than coal. The GHG emissions in the EC scenario is 84.6 million metric tons of CO_2eq which is a reduction of 31.7% amounting to 39.3 million metric tons of CO_2eq compared to the BAU scenario. Reduction in GHG from the EC scenario is as a result of energy efficiency measures taken which led to a reduction in electricity demand and supply.

The REN scenario has the least emissions of the three scenarios: BAU, EC, and REN. The REN scenario has the least emissions because coal power plants were not included in the scenario and the capacity of natural gas power plants was not increased. Therefore, the REN scenario will have electricity supply from wind, solar, hydro, nuclear, biomass and natural gas power plants. With the exception of biomass and natural gas power plants, the remaining power plants do not emit any GHG gasses. Natural gas power plants emit the largest share of GHG amounting to 975.1 thousand metric tons of CO_2eq with biomass emitting 43.8 thousand metric tons of CO_2eq. The total cumulative amount of GHG emissions by REN scenario is 1,018.9 thousand metric tons of CO_2eq.

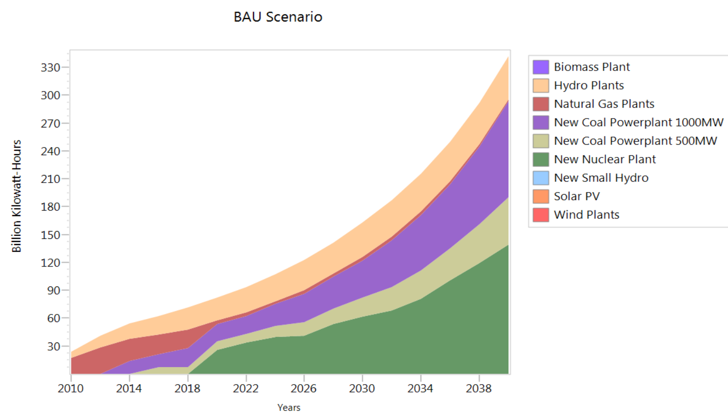

Fig. 3. BAU electricity supply projection

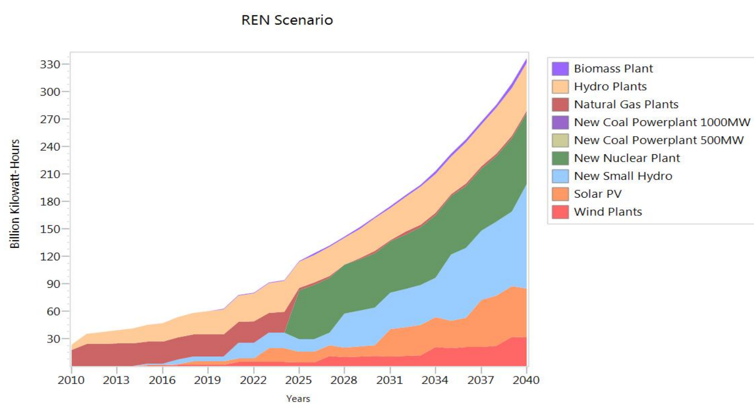

Fig. 4. REN energy electricity supply projection

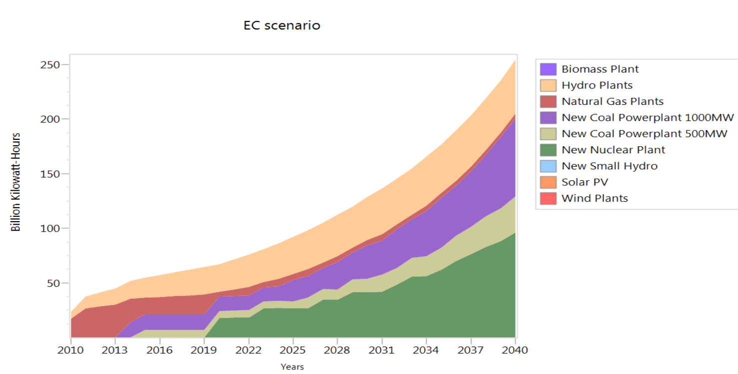

Fig. 5. EC electricity supply projection

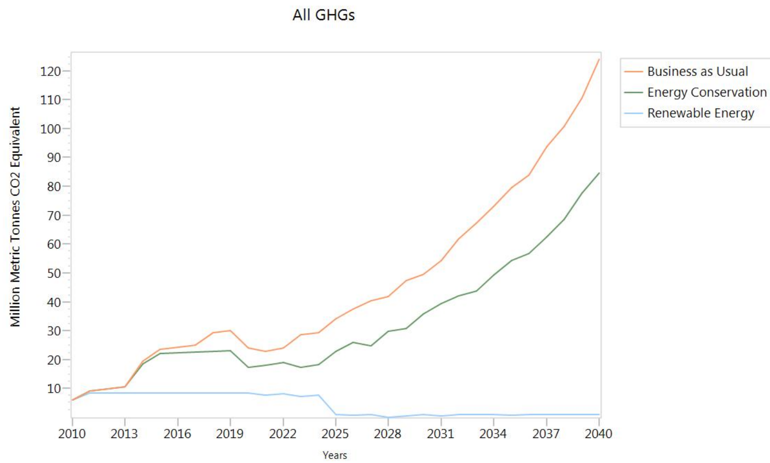

Fig. 6. GHG Emissions Projection

3.4 Cost Analysis

According to [19] in order to view the result of the cost analysis graphically, the costs should be viewed in terms of differences concerning the Reference scenario (BAU).

The cumulative net present value (NPV) of the capital costs in billion USD from 2010 to 2040 of the EC and REN scenarios compared to the BAU scenario is given in Fig. 7. The cumulative capital cost of the EC reached a negative 44.2 billion USD by 2040. This means that the capital cost of the EC scenario is 44.2 billion USD less than the BAU scenario in 2040 (160.2 billion USD). The REN scenario, on the other hand, has a positive cumulative capital cost of 56.3 billion USD, which means that the REN scenario is 56.3 billion USD more than the BAU scenario. The REN scenario is the most expensive scenario in terms of capital costs, while the EC scenario has the least capital costs. The high costs of the REN scenario are attributed to the higher capital costs of the renewable energy electricity generation power plants being introduced.

Fig. 8 shows the cumulative (NPV) of the fixed O&M costs from 2010 to 2040 in billion USD. REN scenario has a positive NPV of 4.1 billion USD and EC has a negative NPV 15 billion USD in 2040. The REN scenario has the highest fixed O&M costs compared to EC and BAU scenarios.

Fig. 9 shows that both the REN and EC scenarios have a cumulative variable O&M cost less than that of the BAU scenario. REN scenario has a negative NPV of 789.4 million USD, EC, on the other hand, has negative NPV of 263 million USD as of 2040. The REN scenario has the lowest variable O&M costs which are attributed to the fact that renewable energy power plants utilize natural energy resources that are available at no costs.

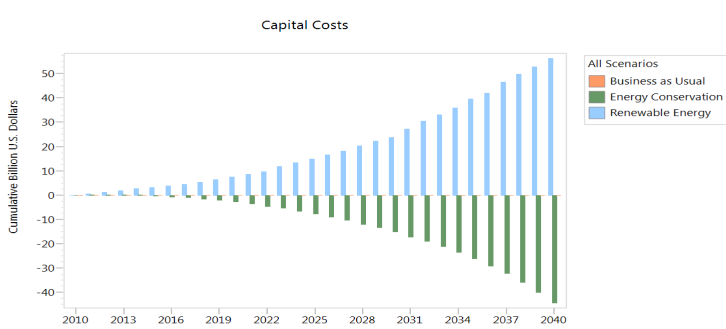

Fig. 7. Bau and EC scenario compared to REN scenario capital costs

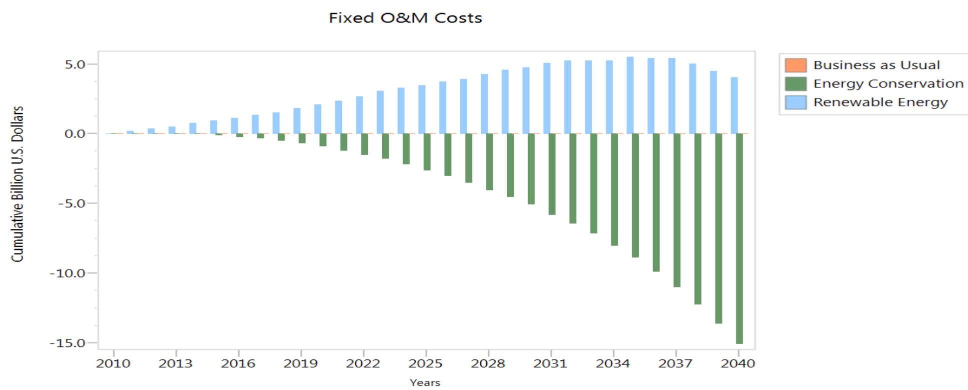

Fig. 8. Bau and EC scenario compared to REN scenario fixed o&m

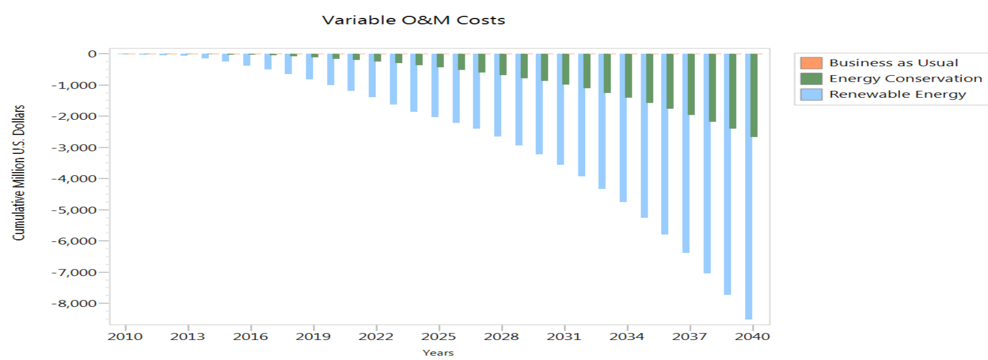

Fig. 9. Bau and EC scenario compared to REN scenario variable o&m

4. CONCLUSIONS

The main objective of this study is to find a solution to the never-ending power outages in Nigeria. Therefore, three scenarios which are BAU, EC and REN were generated. Projections of the three scenarios in terms electricity demand and supply, GHG emissions and costs analysis were made using Long Range Energy Alternatives Planning (LEAP). These projections were used to compare the three scenarios and to decide which path should be followed to meet the growing electricity demand. The summaries of results are presented in Tables 2, 3 and 4.
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The growth in electricity demand in the BAU and REN scenarios is attributed to the electricity access targets set by the Federal Government of Nigeria, which has increased the electricity demand. Electricity demand in the BAU and the REN scenarios reached 283.6 billion kWh in 2040. This demand was 233.8 billion kWh by 2040 in the EC scenario which is 17.55% lower compared to the BAU and REN scenarios. This reduction of electricity demand by the EC scenario is because of the more efficient use of electricity and reduction in transmission and distribution losses.

This reduction of electricity demand in the EC scenario is a major advantage over the BAU and REN scenarios. This is because less electricity demand leads to a reduction in the amount of electricity to be supplied. The electricity supply in the EC scenario is 254.1 billion kWh, 341.7 billion kWh in the BAU scenario and 336.1 billion kWh in the REN scenario by 2040. This clearly shows that there is a 25.6% and 24.4% of the reduction in the amount of electricity to be supplied in EC scenario when compared to BAU and REN scenarios respectively. This reduction in the supply of the EC scenario will reduce the need for expansion and introduction of new power plants, and this will lead to significant savings on investments for power infrastructure by the Federal Government of Nigeria.

The REN scenario has the least net GHG emissions with 134.62 million tons of CO_2eq when compared to BAU that has 1,414.5 million tons of CO_2eq and EC with 1004.8 million tons of CO_2eq. The EC scenario emits 28.96% less GHG than the BAU because of the reduction in capacity of the power plants in the EC scenario. The REN scenario emits less GHG emissions which leads to a reduction in human hours lost and deaths due to disease from the GHG emissions.

The REN scenario is the most expensive scenario when compared to the BAU and EC scenarios in terms of NPV, capital and fixed O&M costs but has the least variable O&M costs (small compared to capital and fixed O&M costs) because of its utilization of the available free natural resources. The utilization of renewable energy resources which are abundantly available in Nigeria will lead to energy security and reduce the need for imports when Nigeria's oil, natural gas and coal reserves are depleted in the coming decades. The socio-economic aspect of the REN scenario is attractive because of the number of jobs that will be created by the renewable energy sector in Nigeria. As reported by [20] the renewable energy sector is creating jobs at a rate 12 times faster than other sectors in the United States economy. But for a growing economy like Nigeria that is facing economic challenges due to its heavy reliance on fossil fuels for which it has no control over its price, the REN scenario will be unrealistic. The EC scenario is the most attractive one in terms of costs in trying to meet the electricity demand and eradicate power outages.

Comparing the BAU, EC and REN scenarios, the EC scenario is the most realistic and suitable path for Nigeria to follow in order to meet its growing electricity demand. This was acknowledged by a study carried out by the Energy Commission of Nigeria, that adopting energy efficiency to conserve energy is the way forward to solve Nigeria's growing electricity demand [21]. In this regard, the Government of Nigeria established the National Centre for Energy Efficiency and Conservation at the University of Lagos. The Centre was established to conduct research in energy efficiency and conservation.

Table 2. Summary of electricity demand and supply

Scenario	Electricity demand by 2040 (billion kWh)	Electricity supply by 2040 (billion kWh)
Business-as-usual (BAU)	283.6 Billion	341.7
Energy conservation (EC)	233.8 Billion	254.1
Renewable energy (REN)	233.8 Billion	336.1

Table 3. Summary of greenhouse gas emissions

Scenario	Greenhouse gas emissions by 2040 (million tons of CO2 equivalent)
Business-as-usual (BAU)	1,414.50
Energy conservation (EC)	1,004.80
Renewable energy (REN)	134.62

Table 4. Summary of capital, fixed O&M and variable O&M costs

Scenario	Cumulative capital cost compared to BAU scenario by 2040 (billion USD)	Cumulative fixed O&M cost compared to BAU scenario by 2040 (billion USD)	Cumulative variable O&M cost compared to BAU scenario by 2040 (million USD)
Business-as-usual (BAU)	-		
Energy Conservation (EC)	-44.2	-15	-263
Renewable Energy (REN)	+56.3	+4.1	-789.4

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World Bank. World Development Indicators Data; 2015. Available:http://data.worldbank.org/data-catalog/world-development-indicators# (Accessed 13 Jun. 2017)
2. USAID. Power Africa in Nigeria Power Africa, U.S. Agency for International Development; 2017. Available:https://www.usaid.gov/powerafrica/nigeria (Accessed 26 May 2017)
3. Heaps CG. Long-range Energy Alternatives Planning (LEAP) system. [Software version: 2017.0.11] Stockholm Environment Institute. Somerville, MA, USA; 2012. Available:https://www.energycommunity.org
4. Park N, Yun S, Jeon E. An analysis of long-term scenarios for the transition to renewable energy in the Korean electricity sector. Energy Policy. 2013;52:288–296.
5. Amirnekooei K, Ardehali M, Sadri A. Integrated resource planning for Iran: Development of reference energy system, forecast, and long-term energy environment plan. Energy. 2012;46:374–385.
6. Kale R, Pohekar S. Electricity demand supply analysis: Current status and future prospects for Maharashtra, India. Renewable Sustainable Energy Rev. 2012;16:3960–3966.
7. Zhang QY, Tian WL, Wei YM, Chen YX. External costs from electricity generation of China up to 2030 in energy and abatement scenarios. Energy Policy. 2007;35:4295–304.
8. Shin H, Park J, Kim H, Shin E. Environmental and economic assessment of landfill gas electricity generation in Korea using LEAP model. Energy Policy. 2005;33:1261–70.
9. Feng YY, Zhang LX. Scenario analysis of urban energy saving and carbon abatement policies: A case study of Beijing city, China. Procedia Environmental Sciences. 2012;13:632-644.
10. Webmeets. Scenario cost benefit analysis of German electricity market with new energy and environmental policies; 2015. Available:http://www.webmeets.com/files/papers/eaere/2015/1089/Scenario%20costbenefit%20of%20Germany%20for%20EAERE%20conferencev1.pdf (Accessed: 4 June 2017)
11. World Development Indicators (WDI). Nigeria. Data; 2010. Available:http://data.worldbank.org/country/Nigeria (Accessed 14 Jun. 2017)
12. Emodi N, Emodi C, Emodi A. Sustainable strategies for low carbon development in Nigeria. Journal of Scientific Research and Reports. 2016;10(6):1-10.
13. de Almeida A, Fonseca P, Schlomann B, Feilberg N. Characterization of the household electricity consumption in the EU, potential energy savings and specific policy recommendations. Energy and Buildings. 2011;43(8):1884-1894.
14. Sustainable energy for all action agenda (SE4ALL-AA). National Council on Power (NACOP); 2016. Available:http://www.se4all.org/sites/default/files/nigeria_se4all_action_agenda_final.pdf
15. The Renewable Energy Master Plan (REMP). Federal Ministry of Environment; 2013. Available:https://www.iea.org/publications/freepublications/publication/projected_costs.pdf (Accessed 3 June 2017)
16. National Renewable Energy and Energy Efficiency Policy (NREEEP), Energy Commission of Nigeria (ECN) and Federal Ministry of Science and Technology; 2015. Available:www.energy.gov.ng
17. Change IPOC. 2006 IPCC guidelines for national greenhouse gas inventories, 2006. Available:http://www. ipcc-nggip. iges. Or; jp./public/2006gl/index. html
18. National Control Centre (NCC). The Nigeria Electricity System Operator; 2010. Available:http://www.nsong.org/AboutUs/Structure.aspx (Accessed 14 Jun. 2017)
19. Heaps CG. Long-range Energy Alternatives Planning (LEAP) system. [Software version: 2017.0.11] Stockholm Environment Institute. Somerville MA, USA; 2015.

Available:https://www.energycommunity.org
20. Samuelson K. Renewable Energy Industry Creates Jobs 12 Times Faster Than Rest of U.S. [online] Fortune.com; 2017.
Available:http://fortune.com/2017/01/27/solar-wind-renewable-jobs/
(Accessed 8 Jul. 2017)
21. Sambo AS. Paper presented at the “National Workshop on the Participation of State Governments in the Power Sector: Matching Supply with Demand”, 29 July 2008, Ladi Kwali Hall, Sheraton Hotel and Towers, Abuja; 2008.

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