International Journal of Research Publication and Reviews

Journal homepage: www.ijrpr.com ISSN 2582-7421

Tackling Power Inadequency in South-South Region of Nigeria Using Leap Model

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ABSTRACT

Forecasting supply and demand for power is crucial to energy management, particularly when it comes to planning for electricity. Nigeria is a sizable nation with a tendency of steadily rising electricity consumption; as a result, anticipating supply and demand for electricity is necessary to prevent imbalances or energy deficits. Nigeria is used as a case study and the energy model LEAP (Low Emissions Analysis Programme) as a tool. Basically, population, economics, and electrical intensity all affect the demand for power. The goal of this research is to further knowledge and practical use of LEAP-based power demand forecasting. The projected end year is 2025, with 2010 serving as the base year. There are two situations in the simulated model. The scenarios are called Base (BA) and Renewable Energy (RET). The results of both scenarios show that if this model is implemented, Nigeria's end-year energy supply will grow by more than twice as much as that of the base year.

Keywords: Power, LEAP, scenario.

Introduction

Energy is vital to human. It has always been essential to human survival, development, and economic success in a variety of ways (Ozohu-Suleiman, 2021). Because of this, having access to energy continues to be a crucial sign of a nation's economic development and the de facto boundary separating developed from developing countries. A nation's ability to successfully obtain, use, and distribute reasonably priced energy has historically been a critical factor in determining its potential for future prosperity. Until the present convergence of the world into a global community, this has been true since the industrial revolution.

Developing economies also have the challenge of meeting their energy needs for infrastructure, economic expansion, and population increase. The fact that these economies were essentially colonies of the developed economies, with a few notable exceptions, implies that, generally speaking, their ability to supply the energy demands of their inhabitants is typically inadequate. According to data available, a number of problems that keep people from getting electricity when they need it are the reason why these emerging countries continue to face an energy crisis (Enebe et al., 2017). This does occasionally occur, despite the fact that many non-renewable and renewable energy sources have substantial social effects. Still, most of these emerging economies lack robust plans to fulfil the demands of their present populace, let alone those of coming generations. This is the case even if these countries' expanding populations suggest a rise in their power demand.

Methodology

1.1 LEAP Model

A static energy economic and environmental model is the LEAP (Low Emissions Analysis Programme) model. Over 190 nations worldwide have adopted LEAP (Suhono & Sarjiya, 2015). Energy sources, transformations, and requirements may all be computed using the Leap model. Accounting is the modelling approach used in LEAP. The calculation of energy supply or demand involves adding up the energy used in each category of activity. Four primary components from Leap are utilised in energy modelling. Demand, change, and resources are the four main tenets (Batih & Sorapipatana, 2015). Data on population size, population growth, nominal GDP (Gross Domestic Product), GDP growth, the number of household customers, and other characteristics are included in the key assumptions module. Demand module consists of four sectors, they are household, industry, business and public.

1.2 Final electricity demand analysis

The final analysis of power consumption is computed for every branch (sector) and year. Total activity multiplied by power intensity is the formula for calculating power consumption (Perwez et al., 2015).

$$\mathrm{ED}_{\mathrm{b,s,t}} = \mathrm{TA}_{\mathrm{b,s,t}} \cdot \mathrm{EI}_{\mathrm{b,s,t}} \qquad (1)$$

where b is the sector, s is the scenario, t is the period (year), ED is the electrical power demand, TA is the total activity, and EI is the power intensity. Energy intensity may be computed from power consumption and the number of customers in the final electricity demand analysis (Perwez et al., 2015). An alternative definition of energy intensity is the total quantity of energy consumed per GDP unit (Acha, 2014). Total activity is defined as GDP plus the number of customers.

Where EI is electricity intensity, EC is electricity consumption, TC is total customer number, GDP is gross domestic product, b is sector and t is time (year).

1.3 Forecasting method

The electricity demand forecasting in this study is calculated by a very simple model. For household sector, the electricity demand is calculated from the number of household customers and its electricity intensity. Projected number of household customers based on population growth, household size (family member) and electrification ratio.

$$\mathrm{EI}_{\mathrm{b,t}} = \frac{\mathrm{EC}_{\mathrm{b,t}}}{\mathrm{TC}_{\mathrm{b,t}}} \qquad (2)$$

or

$$\mathrm{EI}_{\mathrm{b,t}} = \frac{\mathrm{EC}_{\mathrm{b,t}}}{\mathrm{GDP}_{\mathrm{b,t}}} \qquad (3)$$

Where

$$\mathrm{TC}_{\mathrm{h,s,t}} = \frac{\mathrm{P}_{\mathrm{s,t}}}{H_{\mathrm{s,t}}} . \mathrm{ER}_{\mathrm{s,t}} \qquad (4)$$

Total household sector customers (TCH), people (P), average household size (HS), and electrification ratio (ER) are represented by these four variables. The division of the population number by household size yields the number of households. The electrification ratio, also known as the proportion of homes with electricity, is calculated by dividing the total number of households in Nigeria by the number of houses with electricity (Acha, 2014).

$$\mathrm{ED}_{\mathrm{h,s,t}} = \frac{\mathrm{P}_{\mathrm{s,t}}}{H_{\mathrm{s,t}}} . \mathrm{ER}_{\mathrm{s,t}} . \mathrm{EI}_{\mathrm{h,s,t}} \qquad (5)$$

Where P, HS, ER, s, and t are as previously described, ED and EI represent the residential sector's electricity demand and intensity, respectively. Accordingly, projections of population, household size, electrification ratio, and electricity intensity may be used to compute the power demand forecasts for the household sector (Perwez et al., 2015).

The non-household sector's electricity demand is computed more easily than that of the home sector. This strategy just takes into account two things. These are the GDP and the intensity of electricity.

$$\mathrm{ED}_{\mathrm{i,s,t}} = \mathrm{PDB}_{\mathrm{i,s,t}} . \mathrm{EI}_{\mathrm{i,s,t}} \qquad (6)$$

$$\mathrm{ED}_{\mathrm{b,s,t}} = \mathrm{PDB}_{\mathrm{b,s,t}} . \mathrm{EI}_{b,\mathrm{s,t}} \qquad (7)$$

$$\mathrm{ED}_{p,\mathrm{s,t}} = \mathrm{PDB}_{\mathrm{p,s,t}} . \mathrm{EI}_{p,\mathrm{s,t}} \qquad (8)$$

Where ED is electricity demand while i, b dan p describe branch or sector, business and public.

1.4 Scenario Developments

The study's scenarios may be divided into two primary categories: the Base case, which is the reference expansion plan, and the High RET scenarios, which are the expansion plans that incorporate different renewable energy policies and techniques.

Base Case Scenario

The reference scenario, also known as the Base Case scenario, is derived from the optimisation plans of the government of Southern, Nigeria on energy capacity and the recommended options for mitigation. The present augmentation of generation capacity in the Southern region of Nigeria exhibits a notable growth in thermal power generation, mostly reliant on natural gas (NG) and crude oil (oil).

High RET Scenario

The High Renewable Energy Transition (RET) Scenario aims to comprehensively examine and exploit the maximum capabilities of renewable energy technologies (RETs). Therefore, there is a strong focus on the implementation of renewable energy technologies that are supported by verified domestic capabilities. This scenario posits a policy shift aimed at promoting the extensive development of low emission technologies while concurrently reducing reliance on fossil fuel generation.

3. Results and Discussion

Figure 1 displays the electricity optimisation predictions for both the RET scenario and the base scenario. In both cases, the amount of electricity supplied at the conclusion of the scenario is more than double that of the base year. The basic scenario for 2025 calls for 322.0 GWh of power, which is an increase of 174.7 GWh from 2010. According to the government's policy scenario, there would be a 337.1 GWh increase in power consumption in 2025 compared to 2010 (a rise of 189.9 GWh).

As seen in Figure 1, the base scenario's overall projected power usage is less than the RET scenario. It is as a result of the power's optimism.

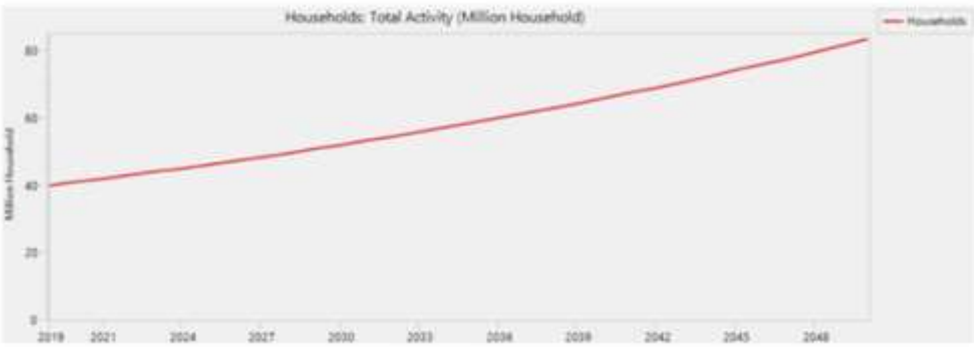

Fig. 1. Electricity Demand in Southern Nigeria 2010-2025

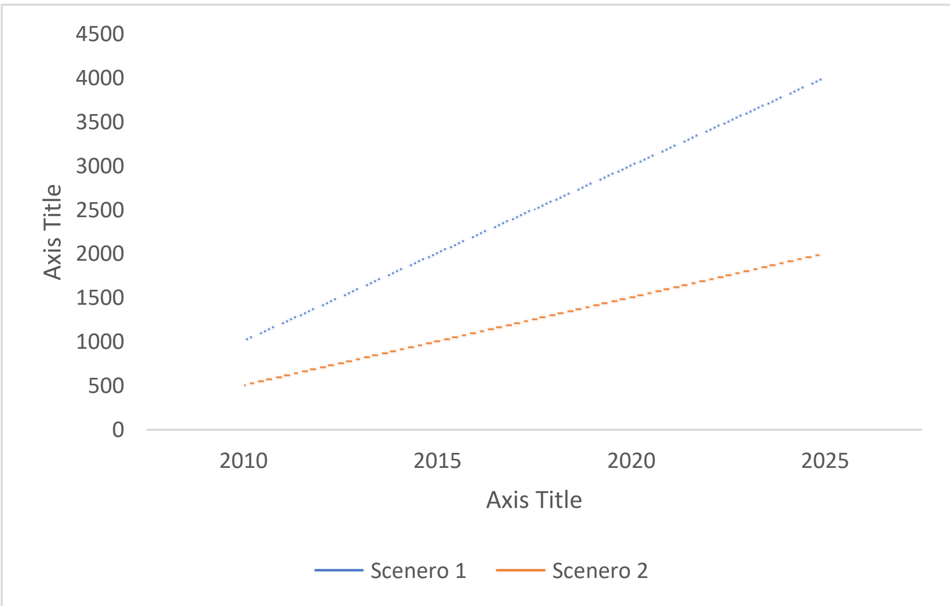

Table 4. Power Optimization Using LEAP

Conclusion

Nigeria's annual population and economic growth have an impact on the country's rising energy usage. A lack of power supply is one of the major issues that might arise from failing to plan for the availability of enough power producing capacity. As a result, estimating the amount of electricity required becomes crucial for organising the future installation of producing capacity. This study examines the forecasted demand for electricity from 2010 to 2025 and suggests a power source that can assist in meeting that need. Population, household size, electrification ratio, number of household customers, GDP, and electricity intensity are the factors that were taken into account for this prediction. Based on the value of the input variable, a straightforward mathematical model computes the power demand projection. There are two base situations and RET scenarios that are simulated. While RET scenarios use data on renewable energy, base scenarios use data averages from 2010 to 2015. As compared to 2010, the results indicate that the supply of power will grow by more than two times by 2025.

Recommendation

Based on the findings of the study, the study recommends that;

1. Renewables along with the distributed generation should be promoted in the country to reduce generation costs and environmental emissions.
2. Indigenous coal should be promoted for energy security and diversity of generation technologies but with abated emissions.

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