POWER SECTOR REFORMS: ENERGY PROJECTIONS FOR SUSTAINABLE NATIONAL DEVELOPMENT

*Mohammed Orah Adamu
Department of Mechanical Engineering Technology, Federal Polytechnic Kaura Namoda, Zamfara State. 08028198356. orahmohammed@yahoo.com
Mohammed Mohammed
Department of Mechanical Engineering Technology, Federal Polytechnic Kaura Namoda, Zamfara State. 08038396499. mmail1mahuta@gmail.com
and
Kayode David Adeosun
Department of Civil Engineering Technology, Federal Polytechnic Kaura Namoda, Zamfara State. 08022674374. kdadeosun2005@yahoo.com
*Corresponding Author: orahmohammed@yahoo.com

ABSTRACT

Development is essential to the sustenance and growth of any nation. The Power Holding Company of Nigeria (PHCN) is saddled with the responsibility of electricity generation, transmission and distribution, but bedevilled with frequent and persistent power outages. Therefore, the federal government embarked on power sector reforms to improve the nation's energy crisis and in turn, reduce the scope of monopoly control of its power industry. The Nigerian vision 20:2020 strategic objective is to ensure that the power sector can efficiently deliver sustainable, adequate, qualitative, reliable and affordable power in a deregulated market. The vision estimated Nigeria would need to generate 35,000MW of electricity by 2020, with a target to grow installed power generation capacity from 6,000MW in 2009 to 20,000MW by 2015 and 35,000MW by 2020. This paper discusses the power sector reforms in Nigeria concerning energy projections to meet with energy demand. Therefore the paper proposes the adoption of an empirical formula for national electricity demand projections from 2020 to 2050 for sustainable socioeconomic development. Results showed that the expected installed power generation capacity by the year 2050 is 140,599MW of electricity, implying that the

country needs many power plants, in a mixed aggregate, to meet this demand. The paper concluded that faithful implementation and commitment of our leaders on the policies developed from electricity demand projections are vital for the achievement of sustainable development in Nigeria. The paper made appropriate recommendations.

Keywords: Reforms, Electricity, Projections, Power plants, Development

Introduction

In 1950, a central body known as the Electricity Corporation of Nigeria (ECN) got established by the legislative council for electricity supply and development. However, other institutions like the Native Authorities and the Nigerian Electricity Supply Company (NESCO) also got licenses for the production of electricity in some locations in the country (Okoro & Chikuni, 2007). Another agency known as the Niger Dams Authority (NDA), was established by an act of parliament, and was responsible for the construction and maintenance of dams and other works on the River Niger and elsewhere, to generate electricity utilizing hydropower. The NDA sold electricity produced to ECN for distribution and sales at utility voltages. The merging of the operations of ECN and NDA formed a new organization known as the National Electric Power Authority (NEPA) in 1972 (Okoro & Chikuni, 2007). From 1972 till early 2006, electricity production and supply had been the monopoly of NEPA, which was responsible for the generation, transmission, distribution and sales of electricity to customers. However, the lack of adequate funding and deficient managerial strategies led to a steady decrease in the performance of NEPA (Adoghe, Odigwe & Igbinovia. 2009). The following identified challenges are the factors affecting the current status of power generation in Nigeria (Sambo, Garba, Zarma & Gaji, 2010):

1. Inadequate generation availability;
2. Insufficient and delayed maintenance of facilities;
3. Lack of funds for power plants;
4. Out-of-date equipment, tools, safety facilities and operational vehicles;
5. Insufficient and obsolete communication equipment;
6. Exploration inadequacies to tap all sources of energy from the available resources;
7. Low staff morale.

The inefficiency and inadequate facilities to boost electricity supply in the spate of increasing population, with new and electronic-based technologies, vast geographical landscape and an increasing

business environment, all combine to create electricity supply problems in Nigeria. While the electricity demand is rising, the supply tends to be falling. This supply inadequacy has a significant damaging impact on all sectors of the economy, therefore, encouraging the people to source for alternative, but unhealthy, electricity supply sources using small power petrol/diesel generators. It generates additional costs to physical health (noise and air pollution) and businesses leading to high prices, discouraging entrepreneurship, encouraging unemployment, elevating poverty and dampening industrial and economic growth (Anwana & Akpan, 2016). Nigeria's installed power generation capacity is 13,400MW, of which 8,000MW is mechanically available. However, less than 4,000 MW has been transmitted on the average, over the last two years due to constraints in gas supply, electricity transmission and distribution (Nhede, 2017). This lack of constant electricity supply has resulted in the weak commitment to the payment of utility bills by consumers, adding to an inherent shortfall in the tariff and the accrued sector cash deficit (Nhede, 2017).

The inadequacies of electricity supply could avert through timely energy projections and diligent implementation. The past three decades have witnessed the population increased to 150 million, with an average GDP growth rate of 6.66%, over the last fourteen years. Within this period, power generation capacity had stagnated (Osueke & Ezeh, 2011). This inadequacies, combined with inadequate maintenance of existing power generation stations, has given rise to severe generation shortages. An estimated 26,561MW would be required in the year 2020 to meet demand as envisioned in the vision 20:2020 target (Osueke & Ezeh, 2011). This study aims at forecasting the electricity demand in Nigeria through a simple empirical formula, projecting values for electricity production from 2020 to 2050.

The Power Sector Reforms

In Nigeria, the electricity demand far surpasses the supply and the supply is epileptic, leading to the country faced with acute electricity problems; this has hindered its development despite the availability of vast natural resources in the country (Sambo, 2008). The National Electric Power Authority (NEPA) now the Power Holding Company of Nigeria (PHCN) is in charge of generation, transmission, distribution and sale of electricity in Nigeria. However, the generated and peak demand for electricity was deficient within the period 1983 to 2003, as shown in table 1 (Adoghe et al. 2009). The idea of the

power sector reform, when successfully implemented, was to turn around the ugly power situation which had drawn back the progress of Nigeria for decades. A state of emergency was announced on the power sector in 2007, to improve the stability of electricity supply, improve cost recovery, and increase the availability of investment capital (Idris, Kura, Ahmed & Abba, 2013).

The PHCN disintegrated into 18 independent companies which are: six electricity generating companies, one electricity transmission company, and eleven electricity distribution companies. The generating companies include the electricity generating company at Egbin, Sapele, Ughelli, Afam, Shiroro and Kainji; and some new Independent Power Producers backed by the Niger-Delta Power Holding Company (NDPHC). The eleven distribution companies are the Electricity Distribution Companies of Abuja, Benin, Eko, Enugu, Ibadan, Ikeja, Jos, Kaduna, Kano, Port-Harcourt, and Yola (Anwana & Akpan, 2016).

Table 1: Electrical energy demand and generated from 1983 - 2003

Years	Energy generated in (GWH)	Peak max
1983	8456	
1984	8927	
1985	10155	
1986	10665	
1987	11191	
1988	11471	
1989	12700	
1990	13364	
1991	14212	
1992	15066	
1993	14617	
1994	14557	
1995	15793	
1996	15771	
1997	15446	
1998	16253	
1999	16291	
2000	15227	
2001	17637	
2002	21544	
2003	22612	

Source: (Adoghe et al. 2009) adapted from Transmission Headquarters annual reports, Oshogbo.

Energy Supply and the Covid-19 Pandemic

The World Health Organization, in March 2020, announced COVID-19 to be a global pandemic (Kanda & Kivimaa, 2020). This infection has infected millions of people and resulted in hundreds of thousands of deaths globally. Nigeria, among all other nations, are struggling to abate the spread of COVID-19, and many countries governments have shut schools, restaurants, cinemas, sports facilities, libraries, and museums (Kanda & Kivimaa,

2020). The COVID-19 caused economic, social, technological, political, and health implications on nations, in addition to environmental and an energetic influence due to restrictive measures, such as lockdown, shelter in place, or stay at home orders, to contain the pandemic at a local level (Abu-Rayash & Dincer, 2020). One significant impact of COVID-19 is the most substantial global equity collapse, worsened by a 60% oil price slump. Also, the social consequences due to COVID-19 resulted in a significant digital transformation, with virtual business, educational and social platforms emerging quickly (Abu-Rayash & Dincer, 2020). This development has led to differences in the arrangement of electricity usage in different countries by the three main customer classes: residential, commercial and industrial. The commercial grade made up of small businesses, manufacturers, and the smaller industry witnessed the most significant decline in activity from the shutdown measures, and consequently, the most significant reduction in electricity demand. Whereas, residential market rose during the pandemic as more people work from home (Shaffer, Leach & Rivers, 2020). Also, hospitals in developed economies struggle to provide medical resources to populations under growing strain from COVID-19.

Healthcare facilities require electricity for health services and medical equipment, and heat for sterilization, space and water heating, and incineration. In the absence of reliable electricity, health workers must carry out work, relying on rechargeable lanterns, torches, candles and mobile phones torches. Vaccines and medications requiring refrigeration cannot be stored, and medical equipment and devices cannot be sterilized or used at all (Broto & Joshua, 2020). Lack of energy access also restricts the provision of emergency care services and the functioning of intensive care units. The ventilators used in intensive care units that this pandemic requires necessitates electricity. A prompt emergency response also depends on reliable energy access. When basic energy services are unavailable, essential components of emergency responses become compromised, including night-time care, refrigeration to keep samples, sterilization facilities or electricity to power simple medical devices (Broto & Joshua, 2020).

Hence, the need for countries, especially developing countries, to make necessary energy projections to meet the energy demand of such nations.

Energy Projections In Nigeria

A significant relationship exists between socioeconomic development and

the availability of electricity. The power supply in Nigeria first began in Nigeria in 1896. In 1952 and 1953, the total electricity consumed was only 77 million kWh, and it grew to 4066 million kWh in 1979-1980; it again grew to be 188340 million kWh in 2008, and finally stood at 19.21 billion kWh in 2011 (Osueke & Ezeh, 2011). Therefore, to produce equitable electricity supply targets and achievements, it is essential to have energy demand and supply projections for the country employing internationally accepted energy modelling methods.

The International Atomic Energy Agency (IAEA) energy modelling tools and the Model for the Analysis of Energy Demand (MAED) and Model for the Energy Supply Strategy Alternatives and their General Environmental Impact (MESSAGE) provided the Nigeria energy demand and supply projections covering the years 2005 to 2030 (Osueke & Ezeh, 2011). Table 2 shows the electricity demand projections for the scenarios. The demand indicated for 2005 signifies suppressed demand, owing to inadequate generation, transmission, distribution and retail facilities. There was no suppressed demand in 2010. It implied that for a 13% GDP growth rate, the demand projections rose from 5,746MW in 2005 to 297,900MW in the year 2030. It requires the construction of 11,686MW of electricity every year to meet the demand. Table 3 shows the corresponding electricity supply projections for each scenario (Osueke & Ezeh, 2011).

Table 2: Electricity Demand Projections per Scenario (MW)

Scenario	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**
Reference (7%)	5,746	15,730	28,360	50,820	77,450	119,200
High growth (10%)	5,746	15,920	30,210	58,180	107,600	192,000
Optimistic I (11.5%)	5,746	16,000	31,240	70,760	137,370	250,000

Source: (Osueke & Ezeh, 2011)

Table 3: Electricity Supply Projections per Scenario (MW)

Scenario	**2005**	**2010**	**2015**	**2020**	**2025**	**2030**

Reference (7%)	6,440	15,668	28,356	50,817	77,450	136,879
High growth (10%)	6,440	15,861	30,531	54,275	107,217	192,079
Optimistic I (11.5%)	6,440	15,998	31,235	71,964	177,371	276,229

Source: (Osueke & Ezeh, 2011)

It is necessary to conduct load forecasting to coordinate transmission and distribution outages over the system and reduce the system failure rate. A long term load forecasting of Nigeria's electricity demand was got employing the stochastic/statistical method (Ezennaya, Isaac, Okolie & Ezeanyim, 2014). This type of forecast helps in making decisions for correcting the imbalance between the power generation and consumption, thus leading to more excellent network reliability and higher power quality. Table 4 shows the total predicted electricity demand from 2013 to 2030. It showed that Nigeria would require about 20,000MW of electricity which is about 300% of the present installed capacity to meet with its millennium development goals by 2030 (Ezennaya et al. 2014).

Table 4: Total Predicted Load Demand

Year	Predicted Load Demand(MW)
2013	14812.99
2014	15093.17
2015	15373.35
2016	15653.53
2017	15933.71
2018	16213.89
2019	16494.07
2020	16774.25
2021	17054.43
2022	17334.61
2023	17614.79
2024	17894.97
2025	18175.15
2026	18455.33
2027	18735.51
2028	19015.69
2029	19295.87
2030	19576.05

Source: (Ezennaya et al. 2014)

3.1 Energy Projections for Electricity Production from 2020 to 2050

The Total Installed Capacity of the operated generating plants in Nigeria was 7,876 MW, but the Installed available Capacity is about 4,000MW as of December 2009 (Sambo et al. 2010). They noted that seven of the fourteen generation

stations were very old and the average daily power generation is below 2,700MW, which is far below the peak load forecast of 8,900MW for the currently existing infrastructure. The result is the massive load shedding experienced across the nation (Sambo et al. 2010). They observed that the electricity demand in the country far exceeds the supply and the supply is irregular; thus, the country suffers acute electricity problems which has hindered its development despite the availability of her vast natural resources (Sambo et al. 2010).

Therefore, a strong correlation between socioeconomic development and the availability of electricity exist. It is imperative to plan electricity production in any nation using available models or relations for sustainable development.

The production of electricity per year can be computed empirically from the expression below:

$$E = E_0 e^{i(t - t_0)}$$

…… (3.1)

Where: E = Electricity Production Required (Mw)

E_0 = Electricity Production in the base year (Mw)

t = time for the production of electricity (Year)

t_0 = the base year (year)

i = Production rate per year. (Yadav, 2007)

This study forecast the electricity demand in Nigeria empirically using the equation (3.1), obtaining projected values for planned electricity production from 2020 to 2050, because the tenure of each successive governments is a four years term. Table 5 shows the average electricity generated by successive governments from 1999 to 2019. It showed that electricity production increased from 3,723 MW in 1999 to 7,000MW in 2019, though the installed capacity at 1999 was about 6,000MW of electricity. The electricity production rate was meagre as a result of the numerous challenges faced in the power sector within the reviewed period. However, the current government planned to increase the electricity generated to 10,000MW by the end of 2019 upon the successful completion of on-going power plants projects. However, this planned capacity could not succeed, as many of the on-going constructions in the power plants were uncompleted. Also, the estimated 26,561MW projected for the year 2020 to meet demand as envisioned in the vision 20:2020 target failed due to lack of proper energy planning and commitment from the government in the construction of the required number of power plants.

Table 5: Average Electricity Production from 1999 to 2019

S/NO	Average Electricity Production (MW)	Tenure Period (Years)
1.	3723	1999 – 2003
2.	4110	2003 – 2007
3.	4521	2007 – 2011
4.	4838	2011 – 2015
5.	6000	2015 - 2019
6.	7000	2019 - 2023

Source: IEA Statistics (2014)

According to IEA statistics (2014), electricity production in 2019 was 7,000 MW, as shown in table 5, and this represents the electricity production in the base year (E_0). The electricity production rate per year is assumed to be 10% considering a high growth rate. The planned electricity production within the period 2020 – 2050 computed using the EXCEL software, obtained the results indicated in Table 6.

Table 6: Electricity Demand Projections from 2020 to 2050

Electricity Production in the Base Year E_0 (MW)	Base Year t_0 (Yrs)	Year of Electricity Production t (Yrs)	Projected Electricity Demand E (MW)
7000	2020	2023	**9449**
9449	2023	2026	**12755**
12755	2026	2029	**17217**
17217	2029	2032	**23241**
23241	2032	2035	**31372**
31372	2035	2038	**42348**
42348	2038	2041	**57163**
57163	2041	2044	**77162**
77162	2044	2047	**104158**
104158	2047	2050	**140599**

The Electricity Production profile in MW for the production time (Year) plotted from

the results obtained in table 6 above is displayed in figure 1 below:

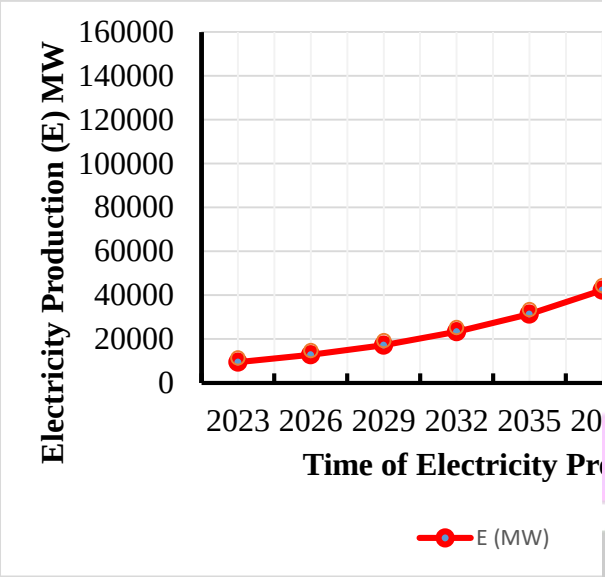

Figure 1: Nigeria's Electricity Projections from the Period 2020 – 2050

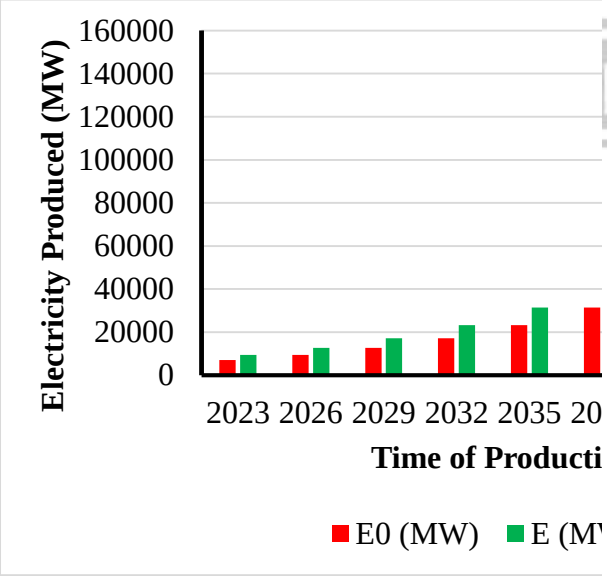

Figure 2: Comparison of Energy production within the period 2020 - 2050

Results and Discussions

The road map to addressing the developmental challenges in Nigeria got launched in 2003 through the National Economic Empowerment and Development Strategy (NEEDS). The primary thrust of NEEDS focused on: empowerment, wealth creation, employment generation and poverty reduction as well as value reorientation (Iheanacho, 2014). It brought forth the idea of the power sector reforms for sufficient electricity production for rapid socioeconomic development. It shows from table 6 that by employing energy demand formula, Nigeria should be generating 9, 449 MW of electricity by 2023 and that by 2035, the country's electricity demand would rise to 31,372MW. It implies that the state should have enough power plants able to generate this amount of electricity and consequently by 2050, it should have an installed capacity of 140, 599MW which is far more than the estimated power of 10,000MW as at 2019.

The current government of President Muhammadu Buhari (GCFR), is determined on improving the power infrastructure in the country. Furthermore, projecting into the future, the country by 2030 should have installed capacity of 17,217 MW compared to the 19,576 MW predicted by Ezennaya et al. (2014) for the year 2030. It could provide a robust system

for much needed sustainable development. It shows from figure 1 that electricity production in MW obtained from the empirical model (formulae) showed a steady geometric increase in the electricity produced in the country. The projections for higher electricity production observed from 2035 to 2050, is a good indicator for achieving the much needed sustainable national development goals. The electricity production in the preceding year compared with the production year is shown in figure 2. The chart shows that from 2035 to 2050, the electricity demand would rise sharply, probably as a result of increased population and human activity. Therefore, the government needs to increase the number of its power plants to fill the energy demand gap.

The significance of empirical energy projections in electricity production is that it allows the government a better assessment of the energy scenario concerning the energy demand in the country. It would aid successive governments in planning the types, complexity, numbers and funding of the power plants to build during their tenures that would meet the energy demand of the country.

Conclusion

One of the main objectives of Nigeria's Vision 20:2020 is that the power sector can efficiently deliver sustainable, adequate, qualitative, reliable and affordable electricity in a deregulated market. Hence, the enactment of the power sector reforms in 2005. The vision reckons that Nigeria would need to install power-generating infrastructure that would increase electricity production from 6,000MW in 2009 to 20,000MW by 2015 and 35,000MW by 2020. However, with the current state of the power infrastructure in the country, this is a far cry. The vision relies heavily on the private sector to take the lead in power generation. Hence, the need for energy projection planning. An empirical formula was applied to forecast the electricity demand within the period of 2020 to 2050. The results showed that the energy demand in 2023 is 9, 449 MW of electricity, close to 10,000 MW proposed by the government for 2019. By 2035, the country's electricity demand would rise to 31,372MW and finally rise to 140, 599MW by 2050.

These projections in electricity production would allow the government a better assessment of the energy scenario for energy demand in the country. It would then aid the federal government in determining the types, nature, complexity, numbers and cost of the power plants to

build to meet the projected demand. Therefore simple empirical formulae should be adopted for electricity demand projections in power development planning in Nigeria and the implementation of the proposed methods would enhance the value of our development plans and ensure that they are practicable instruments of sustainable development in Nigeria.

Recommendations

The following recommendations would ensure sustainable socioeconomic development through planned electricity projections:

1. The Energy Commission of Nigeria (ECN) in collaboration with the National Planning Commission (NPC) should establish a department solely for electricity production planning.
2. ECN should employ appropriate energy planning models and computer programs available for electricity production projections for predicting the amount of electricity to be generated within specified periods and make right projections for the government to implement and fund.
3. Other models, such as the cost projection models for various power plants with the energy required should be employed to assist the government in planning their budgets for power generation.
4. The government should ensure strict implementation and close monitoring of proposed power plants installation, in the correct aggregate mix to include, hydropower, Steam and gas power, and probably nuclear power plants, and ensure timely completion of such projects.
5. Upgrading existing power plants requiring an upgrade would increase their installed generating capacity. Proposed power plants should also be completed during the four years tenure of the current government to prevent the inheritance of uncompleted power projects by new governments.
6. The government should motivate power plants construction, especially for renewable power generation, to achieve increased generation capacity.
7. Our politicians and government bureaucrats in the country need to exercise discipline to ensure that all the objectives of our National Development Plans get achieved.

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