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Article

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Electricity Supply in Nigeria: Cost Comparison between Grid Power Tariff and Fossil-Powered Generator

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ABSTRACT

Electricity supply in Nigeria is a huge problem with great economic and political consequences. After unbundling and privatization of generation and distribution companies, not much improvement has been experienced by electricity consumers; this is due to lack of investment in infrastructure. Lack of investment in infrastructure especially from private investors is caused largely by non-cost reflective tariff among other factors highlighted in this study. While many believe tariff has to be controlled such that it does not go beyond the reach of average citizens, many also believe that the average citizens can pay much more than the current tariff. The latter is evident considering the average amount spend on the use of portable gasoline generators by most homes and small enterprises both in rural and urban centers. The whole life cost method is used to show here that it costs a home or business premise that operates a portable gasoline generator for 6 h daily NGN 37,000/month and costs NGN 157,000 to operate 20 kVA diesel generator. This shows the consumers' capacity to pay the appropriate tariff that can attract investors to the sector.

Keywords: Utility, Tariff, Electric Power Generation Cost, Life Cost Method, Consumer
JEL Classifications: Q43

1. INTRODUCTION

Electricity is essential to modern civilization. As such, it is vital to homes and businesses. The electrification figure in sub-Sahara Africa is very low and needs urgent attention (Oyedepo, 2014). With specific reference to Nigeria, figures show that only 45% of Nigerians have access to electricity (Fakehinde et al., 2019). This access is both epileptic and unreliable (Abdulkareem, 2016; Babatunde et al., 2019; Nnaji, 2011; Nweke et al., 2016) with incessant grid collapse. In order to enjoy electricity when needed, most Nigerian homes and businesses have resulted to the use of captive gasoline and diesel generators due to poor electricity supply from the grid. This, however, comes at a price to both the environment and economics of the nation. While most homes and businesses do not see reasons why the grid-connected (when available) electricity tariff should be reviewed upward, consumers are actually paying multiple of what should be a cost reflective tariff. As a result of low electricity tariff rates in the industry, the electricity supply industry continues to suffer lack of improvements in infrastructure due to inadequate investment that may have been accrued through electricity tariff, while the consumers suffer epileptic supply of electricity. The present electricity tariff models do not have the capability to attract the needed investments. In this study, 5-year whole life-cycle cost analysis was carried out for a 3.3 kVA and 20 kVA gasoline and diesel generators respectively operated for 6 h daily; the cost is analyzed monthly and compared with an equivalent cost of electricity from the grid.

In 2017, it was reported that about 70 million generators of different sizes and capacity are imported into Nigeria in few years, this is based on research by a solar energy company (Ajibade, 2017). The Proliferation of on-site generators in Nigeria is due largely to the challenges of poor and unavailable grid electricity. Some of the factors responsible for this include:

1. Electricity infrastructure deficit: with an available generation capacity of 6,056 MW, transmission capacity of 7,500 MW (Nigerian Electricity Regulatory Commission, 2019), and largely dilapidated and inadequate distribution capacity for a population of more than 180 million, Nigeria is grossly deficient in electricity infrastructure and unable to meet her electricity demand.
2. Government policies and implementations: the government of Nigeria has been carrying out reforms in the electricity supply sector, most impactful among these is the privatization policy. However, these reforms have yielded little results in terms of electricity availability. This is due largely to the mode of implementations and partly due to a few shortcomings in the reform policies. One of such shortcomings is tariff structure.
3. Tariff structure and policy: Despite the reforms being carried out by the government in Nigeria, not much has been done to liberalize electricity pricing and the tariffs are not cost reflective. That the tariffs been not cost effective have such a big implication because the government is privatizing an infrastructure deficient electricity sector and the private investors are expected to invest in these infrastructures. The tariffs are not good enough to attract the needed investments. Furthermore, the tariff structure and component is also not market friendly. For example, as parts of its reforms, government has removed fixed charges. Consumers therefore only pay for energy used and VAT charges, other tariff components (basic charges and demand charges) are not factored into the tariff. Distribution companies can also do better in revenue collections, categorizing consumers and automating billing.
4. The economy and people's purchasing power: liberalizing electricity pricing is understandably tough for the government given the purchasing power and economic viability of the population. The government wants to keep electricity within the reach of an average Nigerian; yet, funds and investment are needed to make the electricity available.
5. Social-economic behavior: Apart from the aforementioned factors that result in the challenges in the electricity sector in Nigeria, it is rather inconsistent that low-income households and small businesses whose electricity cost and sources are studied can actually afford to pay multiples of cost reflective tariffs in generating their own power on site. This is largely due to social-economic behavior of the people. Economic decisions are rarely made as people are constrained to the only choice they can afford at a time and no attempt is made to self-analyze what these decisions cost per week, month or annual. This explains why a small business owner would resist 50% increase in electricity tariff even when they currently spend multiples of that amount generating power on site.

2. ARE MULTIPLES OF COST REFLECTIVE TARIFFS AFFORDABLE? A BRIEF ANALYSIS

2.1. Whole Life Cost Model of On-site Power Generating Set

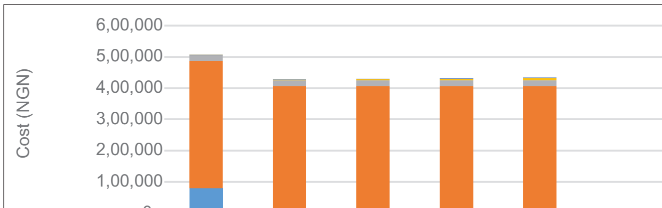
In order to elucidate the affordability of multiples of cost reflective tariffs by consumers, a cost model of on-site generator that includes procurement and installations cost, operating and maintenance cost, and risk cost is presented. These are broad categories of cost; each category can be further divided into several components. In this work, costs of portable gasoline generator and diesel engine generator set used mostly by small businesses, low-income households, and lower mid-class households are modeled using the following cost components:

Procurement cost denoted by "A": Represents the cost of purchase and installations of generator set.

Operating cost denoted by "B": Represents the costs of running the generators, which includes fuel cost and man-hour cost; only fuel cost is considered in this study as man-hour cost is considered insignificant given the type of users in consideration.

Scheduled maintenance cost denoted by "C_1": Represent the cost of planned maintenance activities as recommended by original equipment manufacturer manual (OEM); this could include changing of some components, lubrications, etc.

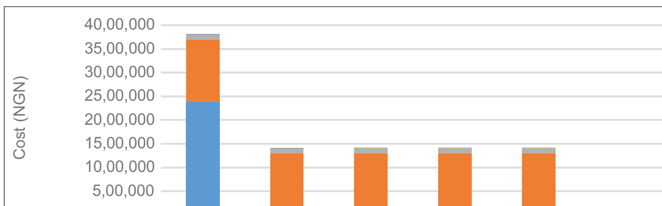
Figure 1: Annual cost model of 3.3 kVA gasoline generator



	Year 1	Year 2	Year 3	Year 4	Year 5
Risk Cost (D)	70	230	390	550	710
Reactive Maint (C2)	700	2,300	3,900	5,500	7,100
Planned Maint (C1)	18,000	18,000	18,000	18,000	18,000
Operations (B)	4,07,121	4,07,121	4,07,121	4,07,121	4,07,121
Renewal (A)	80,000				

Year

Figure 2: Annual cost model of 20 kVA diesel generator



	Year 1	Year 2	Year 3	Year 4	Year 5
Risk Cost (D)	40	165	290	415	540
Reactive Maint (C2)	400	1,650	2,900	4,150	5,400
Planned Maint (C1)	1,00,000	1,00,000	1,00,000	1,00,000	1,00,000
Operations (B)	13,01,955	13,01,955	13,01,955	13,01,955	13,01,955
Renewal (A)	24,00,000				

Year

Reactive maintenance cost denoted by "C_2": represents the cost of unplanned maintenance activities resulting from the breakdown of equipment or its components.

Risk cost denoted by "D": represents the costs resulting from loss of stocks or wares as a result of generator fault, hazard cost resulting from health safety and environment issues relating to the use of generators. For the purpose of this study, only the loss of stocks is considered under this category of cost. Although not considered in this study, the carbon footprint of operating these generators is of huge importance; a liter of gasoline produces 2.3 kg of CO_2, while a liter of diesel produces 2.7 kg of CO_2 (AutoSmart, 2014). Carbon footprint therefore is a huge cost in operations of these generators by millions of these households and businesses across Nigeria but it has not been built into the cost model in this study because there is no price for carbon emissions for these categories of equipment in Nigeria.

The cost model used in this study, therefore, is given in Equation 1 (Asset Management Academy, 2019). The whole Life Cost T is given as:

$$T=A+B+C_1+C_2+D \quad (1)$$

2.2. The Model Cases

The whole life cost of owning and operating a 3.3 kVA gasoline generator and 20 kVA diesel generator used by average family or small enterprise is presented. The generators' specifications and cost components are given in Tables A1 and A2 of the Appendix (Thermocool, 2019). Cost model and analysis is based on Equation 1. The breakdown of the annual cost component for both gasoline and diesel generators of both considered ratings (3.3 kVA and 20 kVA) is presented in Figures 1 and 2.

2.3. Grid Power Cost Equivalent

At year 5, power supply from the gasoline generator cost ₦37,118/month; in kWh this represents:

$$\left(\frac{3.3\,\text{kW}}{2}\right)\times 6\,\text{h}\times 30\,\text{days} = 297\,\text{kWh} \quad (2)$$

Equation (3) gives the cost of 297 kWh from the grid At ₦ 18.94/kWh on Tariff R2SP (Residential type 2 Single phase) (Nigerian Electricity Regulatory Commission, 2015).

$$(297\times 18.94)+\{(297\times 18.94)\times 0.05\,\text{VAT}\}=\text{₦}\,5{,}906.45 \quad (3)$$

Supplying 6 h/day of power from 3.3 kVA generator costs ₦ 37,118 while equivalent supply (6 h/day) from the grid (DISCO) costs ₦ 5,907; this represents approximately 16% of the cost of supplying equivalent power from a portable generator.

While at year 5, power supply from the diesel generator cost ₦ 157,095/month; in kWh this represents:

$$\left(\frac{16\,\text{kW}}{2}\right)\times 6\text{h}\times 30\,\text{days}=1{,}440\,\text{kWh} \quad (4)$$

Equation (5) gives the cost of 1,440 kWh from the grid at ₦ 24.45/kWh on Tariff C1TP (Commercial type 1 Three-phase) (Nigerian Electricity Regulatory Commission, 2015).

$$(1440\times 24.45)+\{(1440\times 24.45)\times 0.05\,\text{VAT}\}=36968.4 \quad (5)$$

Table 1: Grid supply cost equivalent of 3.3 kVA gasoline and 20 kVA diesel generators

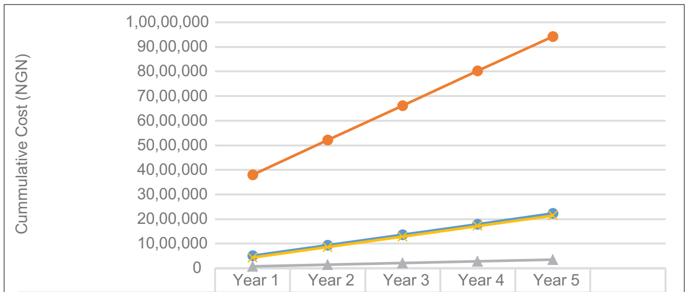
Year	1		2		3		4		5	
	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel	Gasoline	Diesel
Gen capacity (kw)	3.3	16	3.3	16	3.3	16	3.3	16	3.3	16
Connected load (kw)	1.65	8	1.65	8	1.65	8	1.65	8	1.65	8
Hours/day	6	6	6	6	6	6	6	6	6	6
kwh/day	9.9	48	9.9	48	9.9	48	9.9	48	9.9	48
Grid tariff/kwh	18.94	24.45	18.94	24.45	18.94	24.45	18.94	24.45	18.94	24.45
Cost/month (grid)	5,906	36,968	5,906	36,968	5,906	36,968	5,906	36,968	5,906	36,968
Cost/year (grid)	68,440	428,364	68,440	428,364	68,440	428,364	68,440	428,364	68,440	428,364
Cummulative cost/year (grid)	68,440	428,364	136,879	856,728	205,319	1,285,092	273,759	1,713,456	342,198	2,141,820

Table 2: Relationship between captive and grid-connected electricity generation costs

Fuel type	Monthly cost (Grid) (NGN)		Monthly cost (Generator) (NGN)		Generator to grid cost %	Remarks
	R2SP*	C1TP*	Gasoline	Diesel		
Gasoline	5,906	-	37,118	-	628.4	For 6 h of power supply/day, these class of consumers pays 628.4% of the equivalent cost the same services from the grid at current R2SP tariff
Diesel	-	36,968	-	157,095	424.9	For 6 h of power supply/day, these class of consumers pays 424.9% of the equivalent cost the same services from the grid at current CITP tariff

*C1TP: Commercial type 1 three-phase tariff, *R2SP: Residential type 2 single phase tariff

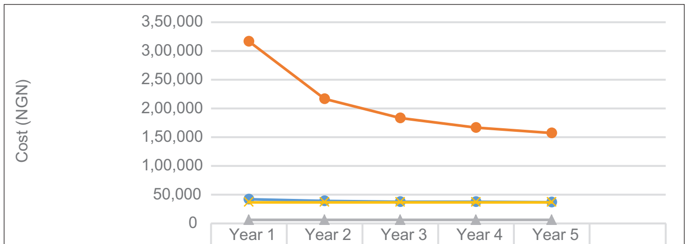
Figure 3: A 5-year cumulative cost



	Year 1	Year 2	Year 3	Year 4	Year 5
Gasoline	5,05,891	9,33,542	13,62,953	17,94,124	22,27,055
Diesel	38,02,395	52,06,165	66,11,310	80,17,830	94,25,725
Grid equivalent (gas)	68,440	1,36,879	2,05,319	2,73,759	3,42,198
Grid equivalent (Diesel)	4,28,364	8,56,728	12,85,092	17,13,456	21,41,820

Year

Figure 4: Monthly cost



	Year 1	Year 2	Year 3	Year 4	Year 5
Gasoline	42,158	38,898	37,860	37,378	37,118
Diesel	3,16,866	2,16,924	1,83,648	1,67,038	1,57,095
Grid equivalent(Gas)	5,906	5,906	5,906	5,906	5,906
Grid equivalent(Diesel)	36,968	36,968	36,968	36,968	36,968

Year

Supplying 6 h/day of power from 20 kVA diesel generator costs ₦ 157,095/month while equivalent supply (6 h/day) from the grid (DISCO) costs ₦36,968/month; this represents approximately 23% of the cost of supplying equivalent power from a diesel generator.

As seen in the graphs of cumulative cost and monthly cost shown in Figures 3 and 4 respectively; at the end of 5 years, operating the 3.3 kVA gasoline generator for 6 h daily costs ₦2,227,055 (₦37,118/month) and operating 20 kVA diesel generator for diesel generator for 6 h daily costs ₦9,425,725 (₦157,095/month) at the end of 5 years.

Table 1 shows the cost of supplying power from the grid at current tariff, these are the grid equivalent of the cost of power supply from 3.3 kVA and 20 kVA diesel generators shown in Figures 1-4. Table 2 shows a comparison of the costs.

3. CONCLUSION

The greatest challenge to the Nigeria electricity supply industry is lack of infrastructure, therefore investment is required from all stakeholders: government and private investors. However, the tariff system does not attract private investment even with parts of the sector owned by private investors. Some of the strongest arguments against having a liberalized or a cost reflective tariff are:

i. poor availability of power; and
ii. the purchasing power of the population.

In this study, the second argument can be disputed given what homes and businesses expend on generating electricity for just 6 h daily. And on the first argument, points have been made in this study that investment is required to ensure improved availability and better tariff is required to attract such investment.

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APPENDIX

Table A1: 3.3 kVA gasoline generator specification

Generator specifications		
	Gasoline	**Diesel**
Generator model	TEC gas generator: Hustlermax 3800Es	Perkins JP20 JET generator
Rating	3.8 kVA (at 0.85 pf) 3.3 kW	20 kVA (at 0.8 pf) 16kW
Fuel consumption	1.3 L/Hr (at 50% load)	2.9L/Hr (at 50% load)
Number of years modeled	5	5

Table A2: 20 kva diesel generator specification

Cost components			
Item	**Cost**	**Gasoline**	**Diesel**
1	Purchasing/Renewal	Acquisition cost: ₦ 80,000	Acquisition cost: ₦ 2,400,000
2	Operating	6 h/day at 1.3 L/h @ ₦ 143/L Other operating cost such as man-hour and pollution not considered	6 h/day at 2.9 L/h at ₦ 205/L Other operating cost such as man-hour and pollution not considered
3	Scheduled maintenance	12 maintenance service per annual at ₦ 1500 per service	4 maintenance service per annual at ₦ 2500 per service
4	Reactive maintenance	This is derived from the probability of failure of the generator hence it Increases with years: MTBF=15.21, Prob. of failure (PoF)=0.07 Annual incremental factor on PoF: 0.16 Repair cost: ₦ 10,000/Repair	This is derived from the probability of failure of the generator hence it Increases with years: MTBF=121.67, Prob. of failure (PoF)=0.008 Annual incremental factor on PoF: 0.025 Repair cost: ₦ 50,000/Repair
5	Risk cost	₦ 1000/failure. This is only the cost of possible item loss Pollution, accident risks are not considered	₦ 5000/failure. This is only the cost of possible item loss Pollution, accident risks are not considered

Inflation considered to be constant over the years