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Investigating the Reliability and Viability of Embedded Generation to Improve the Power Supply (Eleme, Rivers State as a Case Study)

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Abstract: The issue of viability is of great concern in our daily life. Since Eleme is becoming an industrial hub of Port Harcourt City and a preferred location for most of the industries, considerable share of the electric power supply should be directed towards the area. The people in Eleme have been faced with erratic power supply and this is associated with their livelihood; all power consumers are victims of the problem. Especially for factories and industries, it is really challenging to tolerate power interruption since it causes much revenue loss within hours of interruption. So the root cause of this problem should first be identified and the possible solution should be investigated.

This paper covers, investigating reliability and viability of Embedded Generation to improve the power situation in Eleme. The scope will be limited to using the option of power gas turbine technology to generate the electricity. Over the years, all effort to achieve reliable and viable power supply through centralized generation have not yielded any meaningful result, so there is an urgent need to seek power generation options that reduces the amount of energy lost on the grid and to do this in an affordable manner.

Electric Power interruption is affecting many sectors in Eleme. Hence, the primary aim of this study is to assess the power system viability challenges and their enhancement using Embedded Generations. This will be achieved through the investigation into the main causes of power interruptions in Eleme; the investigation into the reliability and viability of using Embedded Generation to improve the power situation in Eleme. From the investigations, relevant conclusions and recommendations will be drawn.

I. INTRODUCTION

Just as no human being can survive without the flow of blood, no nation or city can develop without reliable electricity. The developed nations rode on reliable electricity to attain and sustain their present status. Today, they can boast of years of uninterrupted power supply which have helped their industries, utilities, hospitals, schools, etc to make life comfortable for their citizens.This means that, we can comfortably say that no nation can move from an underdeveloped status to becoming a developed nation without reliable electricity; no reliable electricity, no development. Sustainable developments have continued to elude Nigeria as a nation due to lack of reliable electricity.

Nigeria, like most other developing countries, is grappling with the task of providing sufficient amounts of electricity to meet its needs and fuel its development. The government has, to this purpose, committed to the construction of more electricity generation plants. While this seems like a good idea – increase the amount of generated power and when it is sufficient for the country, the country’s power problem is solved – experience has shown that the power problem in Nigeria is much more than just that of generated capacity.

Reliable energy technologies are expected to play a major role in mitigating pressing societal challenges such as climate change and resource depletion, while contributing to domestic energy security. Just as no human being can survive without the flow of blood, no nation or city can develop without reliable electricity. The developed nations rode on reliable electricity to attain and sustain their present status. Today, they can boast of years of uninterrupted power supply which have helped their industries, utilities, hospitals, schools, etc to make life comfortable for their citizens. This means that, we can comfortably say that no nation can move from an underdeveloped status to becoming a developed nation without reliable electricity; no reliable electricity, no development. Sustainable developments have continued to elude Nigeria as a nation due to lack of reliable electricity.

An effective means for reducing (and eventually eliminating) the mismatches between electricity demand and electricity supply by intermittent energy sources are embedded system technologies. Responding to the need for steadier electricity supply, several companies in the power generation industry have started to develop alternative technologies to address this issue. Yet, while the possibility of shifting the supply of electricity to different times enhances the value of the electricity produced, adding embedded system technologies to a power grid also raises the overall investment cost to be borne by plant operators.

According to Fashola, (2016), Nigeria has an installed capacity of 12,000MW. This milestone (12,000MW) will go a long way to improve the power situation in the country, but it will not be sufficient to address our power needs. As at today, what we have (between 3,000MW-4,500MW) is still a far cry to the 12,000MW, which is currently our installed capacity. All efforts to achieve reliable electricity have not yielded any meaningful result; the most recent being the unbundling of Power Holding Company of Nigeria (PHCN), which brought about the spring up to six power generating companies (GENCOs), transmission company of Nigeria (TCN) and eleven distribution companies (DISCOs). This exercise had transferred generation and distribution to private entities with the exception of the transmission company which is still 100% owned by the government. The GENCOs generates the power, TCN evacuates this power and allocate to the DISCOs, so the DISCOs can only distribute allocated power, which is very small compared to what is required.

The main aim of any energy generating company is to distribute electricity to its users in a cost effective, viable and dependable procedure. Unless this power is planned and maintained reliably, it causes adverse economic effect due to interruption costs and power outages on both the utility and its customers (Anbalagan& Ramachandran, 2011). This thesis presents the study of current power generation system reliability assessment of Eleme Petrochemical GTG, analyses its causes and improvements by integrating Embedded Generation. For a power generation to be viable, then it must be reliable in its power supply to its market.

Reliability assesses the power system’s capacity to give energy to its users while maintaining agreeable standards and in the quantity desired, for a specific period of time it is meant for and under the controlling conditions required. There are two aspects of reliability:

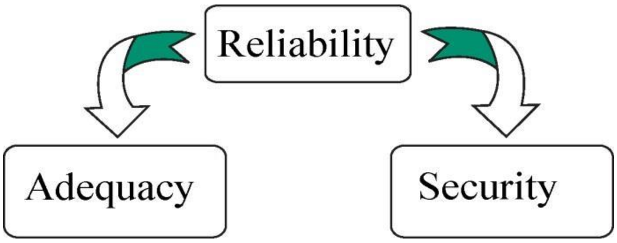


Figure 1: Two aspects reliability (Dan, 2003 & Nurul, 2009)

Adequacy: This means the availability of adequate generating, transmitting and distributing facilities in the power system to gratify the user load requirement at all times; while putting into consideration the planned/ unplanned outages (Dan, 2003 &Nurul, 2009).

Security: refers to the ability of the electric systems to react against to sudden disturbances arising within that system, such as earth fault and short circuit (Nurul, 2009).

As a consequence, adequacy is particularly related with the planning of the grid and security is linked with the operation of the grid.

II. RESEARCH METHODOLOGY

An inductive approach has been followed for the needs of this analysis. In line with this approach, researchers began with specific observations that will lead to generalized theories and conclusions drawn from the analysis. The explanations for occupying the inductive approach was that it takes under consideration the context wherever endeavor is active, whereas it's additionally most acceptable for little samples that turn out qualitative information. However, the most weakness of the inductive approach is that it produces generalized theories and conclusions based mostly solely on a tiny low variety of observations, thereby the dependability of analysis results being underneath question (Denzin & Lincoln, 2005).

A. AREA OF THE STUDY

Indorama Eleme Petrochemicals Limited (IEPL), located in the Indorama Complex at the outskirts of Port Harcourt City, Rivers state, Nigeria, operates state of the art Petrochemical plants, which produces a range of Poly Ethylene (PE) and Poly Propylene products. The PE and PP plants are licensed by Nova Chemicals, Canada and Lyondell Basell of Italy, respectively, and the Olefins plant is licensed by M/s Kellogg Brown & Root of USA. The company has employee strength of around 1500 Nigerian and other Nationalities. The manufacturing plants are well supported by a captive power plant, technical and management support services. The Company was established in the year 1990 under the name Eleme Petrochemicals Company Limited (EPCL) as wholly owned subsidiary of the Nigerian National Petroleum Corporation (NNPC), for meeting the rising demands for plastic resins in Africa.

Eleme is a kingdom and the head of the kingdom is known as the Oneh-Eh-Eleme (The Majesty of Eleme). Beneath him are the paramount rulers of each of the two major groups of towns Oneh Eh Nchia (Chief of Nchia) and Oneh Eh Odido (Chief of Odido). Each Nchia and Odido consist of towns which are further divided into small communities (and then further into areas of the community). The traditional ruler of each town is known as Oneh Eh Eta (Town Chief).

Eleme has two groups of towns, Odido and Nchia, each with their own dialect. The Odido and Nchia languages are mutually intelligible. The Nchia dialect is spoken in the Western areas of the Eleme territory and the Odido dialect is spoken in the east and southeast regions.

Figure 2: *a map of the study area*

B. CASE STUDY

The electrical power system for Eleme Petrochemicals Complex is composed of four package type general electrical model MS6001 gas turbines generators, three emergency diesel engine generators and power distribution equipment. The gas turbine generators (GTG) is connected through a step-up transformer to a 33kV double busbar which can be separated by bus section and bus coupler switches.

The power distribution system is composed of the following substations;

1. Main substation 1 & 2
2. Substation 3 (PPB: Power Plant Building)
3. Substation 4
4. Substation 7
5. Substation 8 (Given to PHEDC)
6. Substation 9
7. Substation 10
8. Substation 11
9. Substation 30
10. Substation 31
11. Substation 32
12. Substation 33
13. Substation 34
14. Substation 35 (EGCB: Emergency Generator Control Building)
15. Substation 61
16. Substation 62

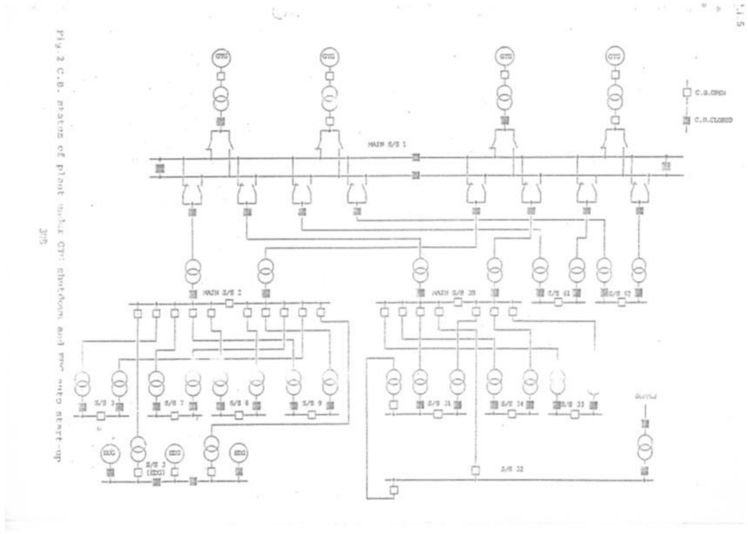


Fig 3: *Line diagram of substation distribution in Eleme Petrochemical*

C. EMERGENCY DIESEL GENERATION (EDG) SYSTEM

The EDG is rated at 3,300 volts, 3 phase and 50 hertz. The three generators are manufactured by Taiyo Electric Co. Ltd type HEKH63Y-6 and the three diesel engines are manufactured by Mitsubushi Heavy Industries, Ltd. Type SI2U-PTA. The EDG provides 415 volts of emergency power via stepped down transformers at respective substation to ensure safe shutdown after the total loss of normal power generated by the GTG and to provide black-out start-up capabilities for the GTG.

D. DATA SOURCES

For this study, both primary and secondary sources of data were consulted. Primary sources of data were gotten directly from the control room daily excel tracker and the technical/logistic unit on the power availability/outage from the embedded generation system of the case study firm. Secondary sources include some published pieces of work by renowned engineering management scholars and educators. As well as online resources such as Electric Power Systems Research journals, Journal of Power Sources and the International Journal on Electrical Engineering and Informatics and many others were also used as secondary sources of data.

E. METHOD OF DATA ANALYSIS: RELIABILITY ANALYSIS

The power system reliability analysis model using Dig Silent Power Factory Software has been selected for the study. Power system reliability analysis of electrical distribution systems will be presented in quantitative procedures given by mean values for load points and the overall system. Power system reliability indices are however used as a means of measuring the reliability of the individual as well as the overall system. So, in this chapter, failure data and basic electrical data of power system equipment which are necessary for reliability analysis will also be collected for the study. It is these data that will be analyzed to identify the current reliability status of the embedded generation system and to distinguish the main problems of interruption. Reliability indices which will be thought of within the study include:

- The quantity of customers;
- The connected load;
- The length of the interruption measured in seconds, minutes, hours, or days;
- The quantity of power (kVA) interrupted; and
- Therefore the frequency of interruptions.

Based on the nature of the data for this study, the researcher used the customer-oriented indices. These indices are directly related to customers. Some of these indices are listed below.

a. System Average Interruption Frequency Index (SAIFI)

It is the mean frequency of continued power disruptions per customer within a particular area. It is the sum of consumers power disruption divided by the sum of consumers served.

$$\text{SAIFI} = \frac{\sum_i \lambda_i N_i}{\sum_i N_i} \quad \text{..} \quad (1)$$

Where;

$\sum_i \lambda_i N_i$ is the sum of consumers power disruption

$\sum_i N_i$ is the sum of consumers served.

λ_i is the failure rate at load point i.

N_i is the amount of consumers found at load point i.

b. Customer Average Interruption Frequency Index (CAIFI)

This index gives the mean frequency of continued power disruptions for consumers experiencing continued power disruptions. The consumer is counted once irrespective of the amount of times disrupted for this calculation.

$$\text{CAIFI} = \frac{\sum_i N_i}{\sum_i N_0} \qquad (2)$$

Where

N_0 is the sum of consumer power disruptions.

N_i is the amount of consumers found at load point i.

c. System Average Interruption Duration Index (SAIDI)

It is basically referred to as consumer minutes or hours of power disruption, and is designed to give information as to the mean time the consumers are disrupted. It is the sum of the restoration time for specific power disruption event multiplied by the number of disrupted consumers for each disruption event divided by the sum of consumers.

$$\text{SAIDI} = \frac{\sum_i U_i N_i}{\sum_i \lambda_i N_i} \qquad (3)$$

Where

U_i is the annual outage time at load point i

N_i is the amount of consumers at load point *i*.

d. Customer Average Interruption Duration Index (CAIDI)

This is the mean time required to bring back service to the mean consumer per sustained power disruption. It is the sum of customer disruption durations divided by the sum of consumer power disruptions.

$$\text{CAIDI} = \frac{\sum_i U_i N_i}{\sum_i \lambda_i N_i} \qquad (4)$$

Where

λ_i is the failure rate at load point i,

U_i is the annual outage time at load point i

N_i is the amount of consumers at load point *i*.

e. Average Service Availability Index (ASAI)

This index connotes the fraction of time (Often in percentage) that a consumers has power provided during one year or the defined reporting period.

$$\text{ASAI} = \frac{\sum_i N_i \times 8760 - \sum_i U_i N_i}{\sum_i N_i \times 8760} \qquad (5)$$

Where $\sum_i N_i \times 8760 - \sum_i U_i N_i$ is the consumers hours of available service

$\sum_i N_i \times 8760$ is the consumer hours demanded

f. Average Service Unavailability Index (ASUI)

This index is the corresponding value to the average service availability index (ASAI).

$$\text{ASUI} = 1 - \text{ASAI} = \frac{\sum_i U_i N_i}{\sum_i N_i \times 8760} \qquad (6)$$

Where $\sum_i U_i N_i$ is the consumer hours of unavailable service

$\sum_i N_i \times 8760$ is the consumer hours demanded

F. VIABILITY ANALYSIS

While the viability of the embedded generation system, cost-benefit analysis will be used to compare set up cost of the embedded generation system with the benefits (profits) accrued from the embedded generation system. More so, the viability will be viewed from an economic perspective; the capital cost of erecting such embedded generation and cost of maintenance/operations shall be used with the current multi-year tariff order (MYTO) structure using simple financial model to determine the viability of using embedded generation to improve the power situation in Eleme.

III. RESULTS AND DISCUSSIONS

A. RELIABILITY AND VIABILITY ANALYSIS OF THE ELEME PETROCHEMICAL GAS TURBINE

Due to NERC regulations, the Eleme Petrochemical GTG do not give (sell) power to the public hence, they generate to serve the plants and their facilities. However, they give 0.5MW to PHEDC for free, PHEDC then sells the generated power from the gas plant to the public without paying back to the Eleme Petrochemical company. Thus, the basis of this reliability analysis shall be on the generated 0.5MW given to PHEDC which is sold directly to consumers in NNPC estate in Port Harcourt, Rivers State which is highlighted yellow in the diagram below.

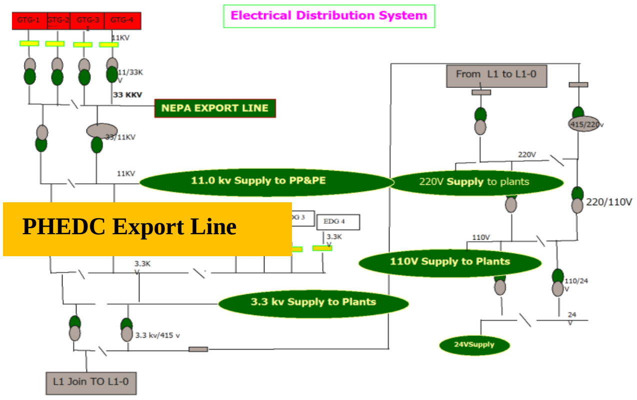


Figure 4: *A Schematic Diagram of Power Distribution System of the Gas Turbine*

The substation 8 provides 0.5MW to power the NNPC estate in Akpajo. The substation 8 comprises of four switch boards connected to a step down transformer. These transformers step down the voltage and then customers will be supplied by their corresponding feeder.

B. POWER INTERRUPTIONS IN ELEME GTG

The Eleme GTG also experience reliability challenges. In summary, Eleme GTG has 3 - 4 interruptions yearly. The interruptions are broken into:

- **Total blackout**: There is a complete loss of main power, but emergency power is available for safe shutdown. This interruption has occurred twice in the last five years; one lasted for 3 hours and the other last for 6 hours. For total blackout, the 66MW is interrupted.
- **Gas Turbine trip**: The duration is about 30 minutes, to allow for the operators to bring up the stand by unit. This happens once yearly. Only 6MW is interrupted.
- **Equipment failure**: This failure does not interrupt power. This happens twice yearly.

C. RELIABILITY ASSESSMENT OF THE SUBSTATION 8 POWER DISTRIBUTION

PowerFactory software is one of power system reliability analysis software. Equipments used in this analysis from the PowerFactory are, lines, breakers, disconnectors, transformers, loads, DG, external grid, busbars and so on.

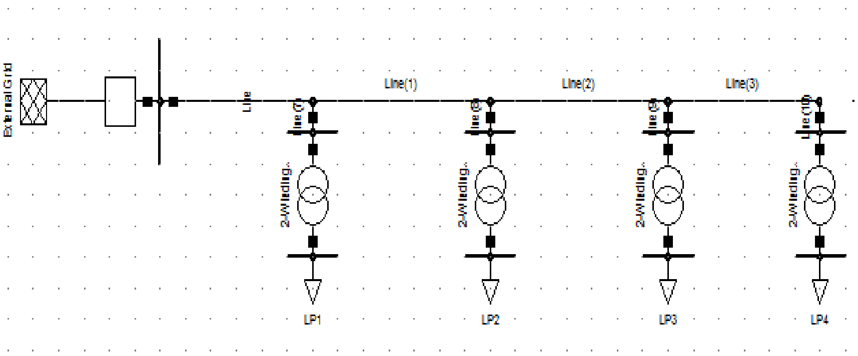
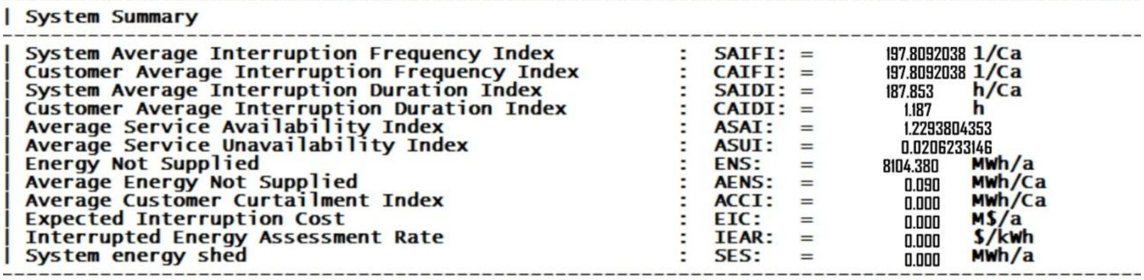


Figure 5: *Line Diagram of Substation 8*

The reliability assessment in this study has two main parts. First, basecase reliability indicesare set using data gotten from PHEDC when the NNPC estate were just using the normal PHEDC utility supply. Second, when the NNPC estate was connected to Eleme GTG for a two year period hence, evaluating the overall improvement on the power supply in the estate.

Table 1: Base case Reliability Indices



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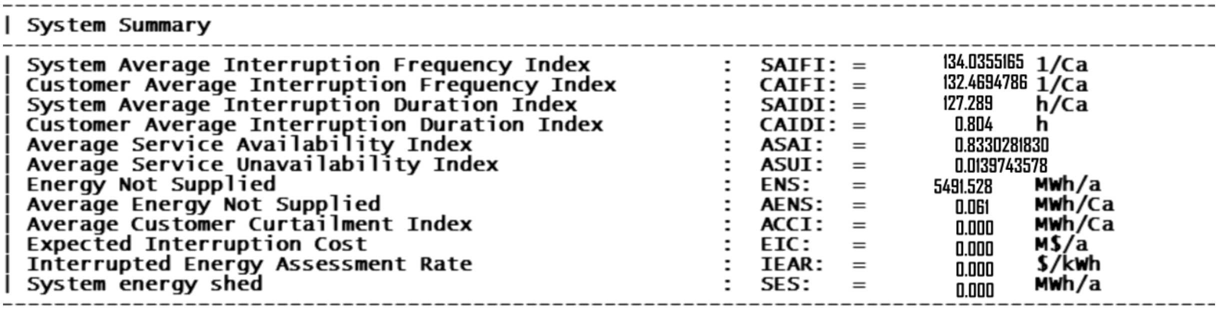
------------------------------------------------------------------------------------------
| System Summary
------------------------------------------------------------------------------------------
| System Average Interruption Frequency Index      :  SAIFI: =    197.8092038 1/Ca
| Customer Average Interruption Frequency Index    :  CAIFI: =    197.8092038 1/Ca
| System Average Interruption Duration Index       :  SAIDI: =    187.853     h/Ca
| Customer Average Interruption Duration Index     :  CAIDI: =    1.187       h
| Average Service Availability Index               :  ASAI:  =    1.2293804353
| Average Service Unavailability Index             :  ASUI:  =    0.0206233146
| Energy Not Supplied                              :  ENS:   =    8104.380    MWh/a
| Average Energy Not Supplied                      :  AENS:  =    0.090       MWh/Ca
| Average Customer Curtailment Index               :  ACCI:  =    0.000       MWh/Ca
| Expected Interruption Cost                       :  EIC:   =    0.000       M$/a
| Interrupted Energy Assessment Rate               :  IEAR:  =    0.000       $/kWh
| System energy shed                               :  SES:   =    0.000       MWh/a
------------------------------------------------------------------------------------------
```

As shown in table 1 above which shows the basecase reliability indices when the estate was connected to the national grid only, the SAIFI and the CAIFI were observed to be 197.8092038 1/Ca, and the SAIDI was 187.853 h/Ca while ASAI was 1.2293804354. More so, ASUI, ENS and AENS were 0.0206233146, 8104.380 Mwh/a and 0.090 Mwh/Ca respectively.

D. GTG SUBSTATION 8 2016 RELIABILITY INDICES

In table 2, below, the reliability indices of the system in the first year of its connection to Eleme GTG had improved by an average of 32.24 percent when compared to it base case indices.

Table 2: Reliability Indices of Substation 8 in 2016



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------------------------------------------------------------------------------------------
| System Summary
------------------------------------------------------------------------------------------
| System Average Interruption Frequency Index      :  SAIFI: =    134.0355165 1/Ca
| Customer Average Interruption Frequency Index    :  CAIFI: =    132.4694786 1/Ca
| System Average Interruption Duration Index       :  SAIDI: =    127.289     h/Ca
| Customer Average Interruption Duration Index     :  CAIDI: =    0.804       h
| Average Service Availability Index               :  ASAI:  =    0.8330281830
| Average Service Unavailability Index             :  ASUI:  =    0.0139743578
| Energy Not Supplied                              :  ENS:   =    5491.528    MWh/a
| Average Energy Not Supplied                      :  AENS:  =    0.061       MWh/Ca
| Average Customer Curtailment Index               :  ACCI:  =    0.000       MWh/Ca
| Expected Interruption Cost                       :  EIC:   =    0.000       M$/a
| Interrupted Energy Assessment Rate               :  IEAR:  =    0.000       $/kWh
| System energy shed                               :  SES:   =    0.000       MWh/a
------------------------------------------------------------------------------------------
```
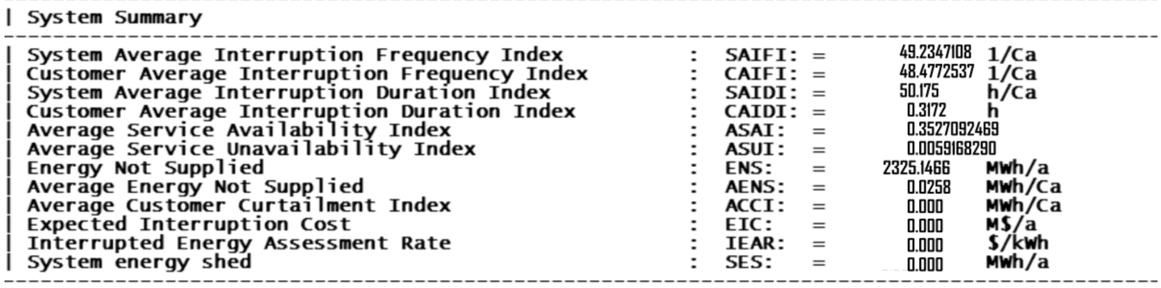

The SAIFI and the CAIFI were observed to be 134.0355165 1/Ca and 132.4694786 1/Ca respectively, and the SAIDI was 127.289 h/Ca, CAIDI was 0.804 while ASAI was 0.8330281830. More so, ASUI, ENS and AENS were 0.0139743578, 5491.528Mwh/a and 0.061Mwh/Ca respectively.

E. GTG SUBSTATION 8 2017 RELIABILITY INDICES

From the result in Table 3 below, reliability indices of the overall system has improved by 75.11 percent when compared to it basecase indices and by 63.27 percent when compared to its first year of connection to Eleme GTG.

Table 3: GTG Substation 8 2017 Reliability Indices



```
----------------------------------------------------------------------------------------------------
| System Summary
----------------------------------------------------------------------------------------------------
| System Average Interruption Frequency Index         :  SAIFI: =      49.2347108  1/Ca
| Customer Average Interruption Frequency Index       :  CAIFI: =      48.4772537  1/Ca
| System Average Interruption Duration Index          :  SAIDI: =      50.175      h/Ca
| Customer Average Interruption Duration Index        :  CAIDI: =      0.3172      h
| Average Service Availability Index                  :  ASAI:  =      0.3527092469
| Average Service Unavailability Index                :  ASUI:  =      0.0059168290
| Energy Not Supplied                                 :  ENS:   =      2325.1466   MWh/a
| Average Energy Not Supplied                         :  AENS:  =      0.0258      MWh/Ca
| Average Customer Curtailment Index                  :  ACCI:  =      0.000       MWh/Ca
| Expected Interruption Cost                          :  EIC:   =      0.000       M$/a
| Interrupted Energy Assessment Rate                  :  IEAR:  =      0.000       $/kWh
| System energy shed                                  :  SES:   =      0.000       MWh/a
----------------------------------------------------------------------------------------------------
```

The SAIFI and the CAIFI were observed to be 49.2347108 1/Ca and 48.4772537 1/Ca respectively, and the SAIDI was 50.175 h/Ca, CAIDI was 0.3172 while ASAI was 0.3527092469. More so, ASUI, ENS and AENS were 0.0059168290, 2325.1466 Mwh/a and 0.0258 Mwh/Ca respectively.

Table 4: Summary of Substation 8 Reliability indices

Indices	**Base Case**	**2016**	**2017**
SAIFI	197.8092038	134.0355165	48.2347108
CAIFI	197.8092038	132.4694786	48.4772537
SAIDI	187.853	127.289	50.175
CAIDI	1.187	0.804	0.3172
ASAI	1.2293804353	0.8330281830	0.3527092469
ASUI	0.020633146	0.0139743578	0.0059168290
ENS	8104.380	5491.528	2325.1466
AENS	0.090	0.061	0.0258

In this case study, it is shown that the GTG Substation 8 reliability indices have a positive impact in the power system's reliability of the estate. That means that the indices were reduced by the integration of the estate to the gas plant power system.

F. MEAN TIME BETWEEN FAILURE (MTBF)

Mean time between failures (MTBF) is that the expected period of time between inherent failures of a system, throughout traditional system operation. MTBF will be calculated because the expectation (average) time between failures of a system. The term is employed in each plant and instrumentation maintenance contexts.

The definition of MTBF depends on the definition of what's thought of a mechanical failure. For complicated, serviceable systems, failures area unit thought of to be those out of style conditions that place the system out of service and into a state for repair. Failures that occur that may be left or maintained in associate degree unrepaired condition, and don't place the system out of service, aren't thought of failures beneath this definition. Additionally, units that area unit taken down for routine upkeep or internal control aren't thought of among the definition of failure. The upper the MTBF, the longer a system is probably going to figure before failing.

MTBF = (Running Hours of GTG) / (Breakdown Hours of GTG)

Table 5: MTBF for Two Years

Year	**Running Hours**	**Breakdown Hours**	**MTBF**
2016	8751	9	972.33
2017	8036.5	3.5	2296.14

The table above shows that year 2016 experienced more breakdown time than year 2017. However, the MTBF of 2017 is better than that of 2016. As reported by the technical crew of the power plant, that they experienced a total power blackout due to some technical faults but it was however rectified hence, the long hour of power breakdown hours in 2016.

G. VIABILITY OF THE ELEME GAS TURBINE GENERATOR

Table 6: Equipments, Installation and Operating

Item	**Amount ($)**	**Amount (N) @ N306**
Equipment/ Installation Costs	24,000,000	7,344,000,000
Cost of gas (Annually)	6,389,359.68	1,955,144,062.08
Salary/Allowances (Annually)	415,500	127,143,000
Variable Costs (Annually)	282,261.66	86,372,067.96
Total	**31,087,121**	**9,512,659,130**

As shown in table 6 above, the total capital cost, installation and operating cost of the power plant in the case study was at 9,512,659,130 billion naira.

Table 7: Various categories of customers and amount per kwh

S/N	**Customer category**	**Description**	**Amount per kwh (Naira)**	**No. of customers per category**
1	R1	Residential	4.00	500
2	R2	Residential	30.23	5,850
3	R3	Residential	48.39	150
4	R4	Residential	50.76	184
5	C1	Commercial	38.96	1,500
6	C2	Commercial	46.72	100
7	C3	Commercial	48.39	40
8	D1	Industrial	41.81	5
9	D2	Industrial	46.72	1
10	D3	Industrial	48.39	2
11	A1	Special	40.60	1
12	A2	Special	45.58	1
13	A3	Special	49.07	1
14	S1	Street lightening	40.62	3

Table 8: Estimated Revenue Generated Per Hour

S/N	**Customer category**	**Description**	**Amount per kwh (Naira)**	**No. of customers per category**	**Amount of kwh used**	**Amount generated per hour (Naira)**
1	R1	Residential	4.00	500	1,200	4800
2	R2	Residential	30.23	5,850	14,032	424187.4
3	R3	Residential	48.39	150	360	17420.4
4	R4	Residential	50.76	184	442	22435.92
5	C1	Commercial	38.96	1,500	3,598	140178.1
6	C2	Commercial	46.72	100	240	11212.8
7	C3	Commercial	48.39	40	96	4645.44
8	D1	Industrial	41.81	5	12	501.72
9	D2	Industrial	46.72	1	2	93.44
10	D3	Industrial	48.39	2	4	193.56
11	A1	Special	40.60	1	2	81.2
12	A2	Special	45.58	1	2	91.16
13	A3	Special	49.07	1	2	98.14
14	S1	Street light	40.62	3	8	324.96
TOTAL REVENUE GENERATED PER HOUR						**626,264.18**

Break-Even Analysis

A break-even analysis predicts the sales volume, at a given price, required to recover total costs. In other words, it’s the sales level that is the dividing line between operating at a loss and operating at a profit.

BEP = Fixed Cost ÷ Contribution margin

Fixed cost = Equipment/Installation Cost+ Cost of gas

= 7,344,000,000 + 1,955,144,062.08

= 9,299,144,062.10

Total Year's income = Revenue Generated Per Hour × (Total Hrs in a year – hours of power outage in that year)

= 626,264.18 × (8760 – 9)

= 626,264.18 × 8751

= 5,480,437,839.20

Contribution Margin = Total Year's Income –Year's Variable Costs

= 5,480,437,839.20 – 213,516,067.96

= 5,266,921,771.20

Therefore, BEP = Fixed Cost / Contribution Margin

= 9,299,144,062.10/5,266,921,771.20

= **1**.76557

From the above calculation, the break-even point (BEP) shows that the capital of the business will be recovered in the 17th month of selling power to Eleme. Thus, the feasibility study shows that the business is viable.

IV. CONCLUSIONS

The reliability is estimated not in terms of the failure rates, but in terms of the number of the critical loads interruptions over a certain period of time; this choice is because the reliability of a system depends on the complexity of the system itself and not only on the number and the failure rates of its components. As observed in this study, the reliability of the Eleme Petrochemical Gas Turbine Generator substation 8 does met the requirements set by NERC. The study showed a progressive improvement in power reliability after the NNPC estate was connected to the Gas turbine generator when compared to when the estate was using only PHEDC utility power supply from the National grid power supply.

Even if the feasibility study showed that the business is viable, this is not the case in Eleme. Most the customers are not metered and don't pay electricity bills which will automatically make the business not viable; the distribution companies directs power to areas that are willing to pay their bills, so they can recoup the investment and remain in business.

V. RECOMMENDATIONS

Any embedded generation company will need to do the following to break even on time and remain in business:

- They must meter all customers with smart meters and put other measures to ensure that customers don't by-pass their meters.
- They will have to do due diligence to ensure that the prospective customers have the capacity to pay their bills.
- They will have to distribute themselves because some of the distribution companies tends to prefer estimated billing as to providing meters for their customers
- They can also work with NERC to agree on a cost reflective tariff

REFERENCES

[1]. Adebayo, I.G and others (2013): "Power System Reliability Analysis Incorporating Distributed Generator," International Journal of Scientific & Engineering Research Vol. 4, Issue 3, ISSN 2229-5518.

[2]. Adnan Anwar, (2012). Distributed Generation Planning for Loss and Cost Minimization in Power Distribution SystemsThe University of New South Wales Canberra, Australia.

[3]. Ahmed M. Azmy and IstvánErlich (2011), "Dynamic Simulation Of Hybrid Fuel Cell/Microturbine Units Integrated Into Large Power Systems," University of Duisburg-Essen, Germany.

[4]. Anbalagan, P and Ramachandran, V (2011): "An Enhanced Embedded Model for Reliability Evaluation of Power Distribution Systems," International Journal of Computer and Electrical Engineering, Vol. 3, No. 4.

[5]. Anders Hegvik, (2012). Case Study Analysis of Running Distributed Generators in Island Mode Effects on Reliability of Supply. Norwegian University of Science and Technology.

[6]. Andrew Keane, (2007). "Integration of Distributed Generation University", University of Ireland.

[7]. Angel Fernandez Sarabia, (2011). Impact of distributed generation on distribution system. Aalborg, Denmark.

[8]. Fortoul, C. F. G.-L, (2005). Review of Distributed Generation Concept: Attempt of Unification. Proceeding of International Conference on Renewable Energies and Power Quality. España.

[9]. Dan Zhu, (2003): "Power System Reliability Analysis with Embedded Generators," MSc. thesis, Blacksburg, VA.

[10]. Fashola, B.R (2016, April 26):"Only 50 of Nigeria's 140 Turbines Generate Power Now", (M. Ogun, Interviewer). Retrieved from https://www.thisdaylive.com/index.php/2016/04/2016/fashola-only-50-of-nigerias-140-turbines-generate-power-now/.

[11]. Francesc Xavier BellartLlavall, (2011). Reliability worth assessment of radial system with distributed generation. Illinois Institute of Technology, Chicago.

[12]. Greg Rouse and John Kelly, (2011). Electricity Reliability: Problems, Progress, and Policy Solutions. Galvin Electricity Initiatives.

[13]. Sneha, J. A., Kumar, K., Victor, V. B. & Glenn, J. A., (2014). Optimal Placement of Different Types of DG Sources in Distribution Networks Using PSO Algorithm and Differential Evolution. IOSR Journal of Electrical and Electronics Engineering (IOSR-JEEE) e-ISSN: 2278-1676, vol.9, p-ISSN: 2320-3331, Issue 4 Ver. PP 41-45.

[14]. Virk, J. S. and Ghosh, S. (2012). Improvement in Reliability Analysis using Distributed Generators. International Journal of Scientific & Engineering Research Vol.3, Issue 5, ISSN 2229-5518.

[15]. Japinder P. Singh V. and Smarajit G., (2012). "Improvement in Reliability Analysis using Distributed Generators". International Journal of Scientific & Engineering Research Vol. 3, Issue 5, ISSN 2229-5518.

[16]. Kasmawati B. R., (2014). Planning and Impact Of Distributed Generation In SESB Existing System. University Tun Hussein Onn Malaysia.

[17]. Leonel de Magalhães C., (2008). Using Evolutionary Swarms (EPSO) In Power System Reliability Indices Calculations. Porto, Portugal.

[18]. Lokesh P. M., (2008). Reliability assessment of a power grid with customer operated CHP systems using Monte Carlo simulation. University of Massachusett.

[19]. Mohamed T. and Mohamed E., (2010). The Effect of Distributed Generation on Power System Protection. University of Exeter.

[20]. Rugthaicharoencheep, N. and Langtharthong, T. (2011). Reliability Improvement with Optimal Placement of Distributed Generation in Distribution System.

[21]. Nagasmitha A., (2007). Dynamic modeling and simulations of solid oxide fuel cells for grid-tied applications. University of Missouri-Rolla.

[22]. Nurul I. (2009): "Placement impact of Embedded Generation in distribution networks", University Malaysia Pahang**.**

[23]. Anbalagan, P. and Ramachandran, V. (2011). An Enhanced Distributed Model for Reliability Evaluation of Power Distribution Systems. International Journal of Computer and Electrical Engineering, Vol. 3, No. 4.

[24]. Peyman M. and Sreenivas, G.N. (2013). Reliability Analysis of a Radial Distributed Generation Distribution System.

[25]. Billinton, R. and Allan, R. N. (1984). Power-system reliability in perspective. IEE Electronics and Power. Vol. 30, No. 3.

[26]. Richard J. C., (2012). Weather-Related Power Outages and Electric System Resiliency. Congressional Research Service, USA.

[27]. Robert P. B., (2007). Electric Distribution Reliability Analysis Considering Time-Varying Load, Weather Conditions and Reconfiguration With Distributed Generation. Blacksburg, Virginia.

[28]. Chapel, S. (2000). Reliability of Electric Utility Distribution Systems. Electric Power Research Institute Inc., Santa Clara University, USA.

[29]. Saifur R., Manisa P. and Virgilio C., (2008). Impacts of Distributed Generation on the Residential Distribution Network Operation. Falls Church, Virginia.

[30]. Salman K. (2014). Reliability modeling and evaluation of distributed energy resources and smart power distribution systems. Lincoln, Nebraska.

[31]. Solomon D. (2013). Study on reliability improvement of Adama city power supply using smart grid. Addis Ababa University.

[32]. Suchismita, S. D. G. (2006). A Reliability Assessment Methodology for Distribution Systems with Distributed Generation. Texas A&M University.

[33]. Tempa D. (2009). Reliability Assessment of Distribution Systems. Norwegian University of Science and Technology.

[34]. Truptimayee P. (2009). Islanding detection in distributed generation. National Institute of Technology, Rourkela.

[35]. Walmir F. J. C. (2006). Planning and impact of distributed generation in existing system. University Tun Hussein Onn, Malaysia.

[36]. Hegazy, Y.G., Salama, M.M.A. and Chickhani, and A.Y. (2012). Distributed Generation and Distribution System Reliability. Abbasia, Cairo, Egypt.