POWER DEMAND OF TRANSFORMERS IN COMMERCIAL NERVE CENTRES IN NIGERIA – BENIN CITY AS A CASE STUDY.

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ABSTRACT

Since independence, Nigeria has never known constant power supply and smooth distribution of power. Power demand is of paramount interest to the electrical engineer concerned with the generation, transmission, and economic implications of electric energy. This situation is so due to the technical and economic implications of electric energy production/consumption. Benin City as one of the load infested areas in Nigeria could provide a solution to the problem of stabilizing power supply in Nigeria if carefully studied. This study reveals that the power demand in Benin City has been on the increase. This is an eye opener to the PHCN (Power Holding Company of Nigeria), which must take appropriate measures necessary to accommodate this increasing power demand. The study further reveals that the Brewery factory in Guinness injection substation has the highest load density with a value of 102.0 VA/m^2 this is due to the running of motors for 24/7 hours. The lowest load density is that from the Dam feeder in Ikpoba Dam., with a value of 0.3$VA/m^{2.}$

Keywords: injection, power demand, substation, transformers, transmission.

INTRODUCTION

Electrical energy demand in Nigeria is on the increase due to the ever increasing population and the attendant increase in commercial and industrial activities. This is even worse in urban centres where the population is concentrated due to rural to urban drift in populations. [Michael, 1972]

As power demand grows with population growth the generation, transmission and distribution networks must be strengthened to cope with the consequent technical and economic shortfalls. With increasing power demand, the loading of the generators, transformer, transmission lines and all the associated switchgear also increase. Hence, concerted efforts must be made to monitor the pattern of this power demand so that appropriate financial and technical measures can be taken to enhance the status of the power distribution/transmission network equipment..

A load survey of this nature is necessary because, with increasing demand for power all the distribution network equipment will have to handle larger normal and fault current levels, hence complexity and cost of protective gear required will also increase. [Theraja, 1995]

This study will help the power utility engineers to plan for and forecast future trends in power demand, and thus be able to take appropriate techno-economic measures necessary to forestall power outages. This will make for a stable power supply and improve the standard of living of the citizenry (consumers). A network diagram for Benin City is shown in Fig 1.0

MATERIALS AND METHODS

This study being rather a load survey is a statistical problem. In this case injection sub-stations in Benin City with their distribution transformers were surveyed, in order to achieve a good estimate of power demand, the KVA rating and KVA readings for every one hour for one week were taken and recorded. Some consumer loads were also measured and recorded.

Certain performance factors such as average demand, maximum demand factor, diversity factor, load factor, load density and coverage area, were investigated in this study, where

$$\text{Average Load} = \frac{\text{Kwh consumed during the period considered}}{\text{Hours in the period considered}}$$

$$\text{Demand Factor} = \frac{\text{Maximum demand}}{\text{Total Connected Load}} \quad \text{(usually < 1)}$$

$$\text{Diversity Factor} = \frac{\text{sum of individual maximum demand}}{\text{Maximum demand of the entire load}}$$

$$\text{Load Factor} = \frac{\text{Average power per year (or per month or per day}}{\text{Maximum demand}}$$

$$\text{Load Density} = \frac{\text{Capacity of transformer in KvA}}{\text{Area Covered by transformer in m}^2}$$

$$= \frac{\text{Load}}{\text{Area Covered by Load}}$$

The various classes of consumers surveyed include the residential consumers, commercial and industrial consumers. The seven injection substations selected for the purpose of this study are Etete, Nekpenekpen, Ugbowo, Ikpoba dam, Guinness, Siluko and GRA injection substation, the rated powered and voltage ratios of transformers, and load reading were taken

RESULTS

Table 1: Rated Power And Voltage Ratios Of Injection Substation Transformers

s/no	Name of Injection substation	Rated Power	Rated Voltage Ratio of Transformer
1	Etete	20.5MW	33/11KV
2	Nekpenekpen	13.5MW	33/6.6KV
3	Ugbowo	13.5MW	33/6.6KV
4	Ikpoba Dam	6.6MW	33/11KV
5	Guinness	12.3MW	33/11KV
6	Siluko	20.5MW	33/11KV
7	GRA	13.5MW	33/11KV

TABLE 2: Reading Of The Rated Capacity Of Injection Substation Transformers

S/no	Name of Injection Substation	Rated Capacity
1	Etete	22.5MVA
2	Nekpenekpen	15MVA
3	Ugbowo	15MVA
4	Ikpoba Dam	7.5MVA
5	Guinness	15MVA
6	Siluko	22.5MVA
7	GRA	15MVA

TABLE 3: Feeders In Each Injection Substation

Name of Injection Substation	Names of Feeders
Etete A	Sapele road A1, Ihama Road A2, Ugbor A3 Dumez Road A4
Nekpenekpen B	Feeder 1, B1, Feeder 2, B2, Feeder 3, B3, Feeder 4, B4
Ugbowo C	Federal Girls Road, C1 Uselu Road, c2 Edaike C3 Ugbowo, c4
Ikpoba Dam D	Okoro Road, D1, Uselu Road D2, Edaike D3, Dam D4
Guinness E	Brewery E1, New Benin E2, Auchi Road E3 Asaba Road E4
Siluko F	Uwelu Road F1, Edo Textile F2, Oliha F3, Upper Siloko Road F4
GRA G	Palace G1, Sapele Road G2, GRA G3, Reservation G4

The total individual load in KVA and the coverage area in m^2 of each injection substation were estimated and tabulated as shown in table 4, the coverage area being the space of land inhabited by consumers.

Table 4: Calculated Total Load

s/no	Injection substation	Feeders	Load (KVA)	Area (m^2) (space of land covered by consumers	Total load	Total Area (m^2)
1	Etete	Sapele road Ihama road Ugbor road dumez road	7300 13315 700 1200	86180 453440 578730 62500	38.815	1180850
2	Nekpenekpen	Feeder 1 Feeder 2 Feeder 3 Feeder 4	5400 7900 9750 3600	2654060 9433610 6823410 28887080	26.650	51279040
3	Ugbowo	Okhoro road Upper lawani Dam	2300 2300 900	73540 10506320 38899780 1708940	13.600	42454100
4	Guinness	Brewery New Benin Auchi Road Asaba road	7500 57600 2650 7115	459900 1046710 1551690 358780	23.025	161178580
5	Siluko	Uwelu road Edo textile Upper Siluko Oliha	1900 7000 4100 7900	1667370 231000 5888610 3477900	20.900	6646140
6	Gra	Palace Sapele GRA Reservation	7650 800 9000 7400		24.850	11265080

From table 4, the individual load density can be determined for each feeder. Considering, for example the Sapele Road feeder in Etete injection substation, we have:

Total load = 7300 KVA

Total area = $86180m^2$

Therefore load density = load/Area Covered by load = $7300 \text{ KVA}/86180m^2 = 0.0847 \text{ KVA}/m^2 = 84.7\text{VA}/m^2$

Repeating the above procedure for all the feeders in table 4 result in table 5 shown blows with an additional column for load density in KVA/m^2

Table 5: Load Densities of the Injection Substation.

Injection substation	Feeder	Total Load (KVA)	Coverage Area (m^2)	Load Density (KVA/m^2)
Etete	Sapele Road Ihama Road Ugbor Road Dumez Road	7300 13313 6700 1200	86180 453440 578730 62500	0.0847 0.0294 0.0168 0.0192
Nekpenekpe	Feeder 1 Feeder 2 Feeder 3 Feeder 4	5400 7800 9750 3600	6254060 6326670 40359200 1939110	0.0020 0.00012 0.0002 0.00019
Ugbowo	Federal Girl Road Uselu Road Egua Edaken Ugbowo	2900 5400 2500 8400	4469060 6326670 40359200 1939110	0.0006 0.0007 0.00016 0.0004
Ikpoba Dam	Okhoro Road Upper Lawani Dam	2300 2300 9000	6743610 6823410 28887080	0.0003 0.0007 0.0003
Guinness	Brewery New Benin Auchi Road Asaba Road	7500 5760 2650 7115	73540 10506320 3889780 1150450	0.1020 0.0005 0.0007 0.00062
Siluko	Uwelu Road Edo Textile Upper Siluko Road Oliha	1900 7000 4100 7900	459900 104710 1488690 358754	0.00041 0.0067 0.0022 0.0028
GRA	Palace Sapele GRA Reservation	7600 800 9000 7400	1687570 231060 5888610 3477900	0.0045 0.0035 0.0015 0.0021

Daily Observation of maximum KVA Power demand was carried for 21 Consecutive days at each of the injection substations and the result were recorded as shown in table 6

From table 6, the load and demand factors can be calculated for each injection substation as follows:

For Etete injection substation: Day 1

Total KVA m. d = 9248 KVA

Average demand = 9248/42 = 389.5 KVA

Maximum demand per 30 minutes = 510 KVA

Total connected load = 38815 KVA

Load factor = Average demand/Maximum demand = 38915 / 510 = 0.7637 = 76.4%

Demand factor = Maximum demand / Total connected load = 510 / 38815 = 0.01321 = 1.31%

The same procedure is repeated for other injection substations.

CONCLUSION

The **Brewery injection substation feeder** has the highest load density of 0.102 KVA/m^2 and the **dam feeder at Ikpoba dam injection substation,** the lowest at 0.003 KVA/m^2. The heavy industrial and commercial activities around the brewery area could have motivated PHCN to supply more of its available power to this area, considering the enormous financial returns on invested capital.

RECOMMENDATIONS

(a) There should be a map showing the connectivity of the houses in the various substations in Benin metropolis

(b) Any new house connected to the grid should be recorded for effective tariffs

(c) Records of Updated appliance in use by consumers should be sent to PHCN to enable them upgrade the various substations.

(d) To enable corrective repairs, all tariffs should be paid promptly

(e) Proper computerization should be encouraged.

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Table 6 Maximum Power demand

S/N	Injection Substation	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8	Day 9	Day 10	Day 11	Day 12	Day 13	Day 14	Day 15	Day 16	Day 17	Day 18	Day 19	Day 20	Day 21
1.	ETETE	510	480	520	516	576	560	540	520	514	490	510	550	520	522	515	510	485	520	550	510	515
2.	NEKPENEKPEN	400	390	400	410	450	440	440	420	400	410	420	452	420	405	450	410	440	425	440	450	440
3.	UGBOWO	410	410	410	420	440	430	420	410	420	410	410	430	430	440	420	420	410	420	440	430	420
4	IKPOBA DAM	550	460	500	492	504	570	480	500	460	480	520	520	500	500	480	550	560	490	504	500	480
5.	GUINESS	440	464	480	480	540	520	520	520	510	480	480	540	430	440	460	480	520	510	500	540	500
6.	SILUKO	530	510	540	540	560	570	570	520	530	530	520	510	540	540	540	510	510	560	560	560	570
7.	GRA	270	336	300	300	312	330	330	280	285	280	300	310	320	330	328	300	270	300	330	330	335

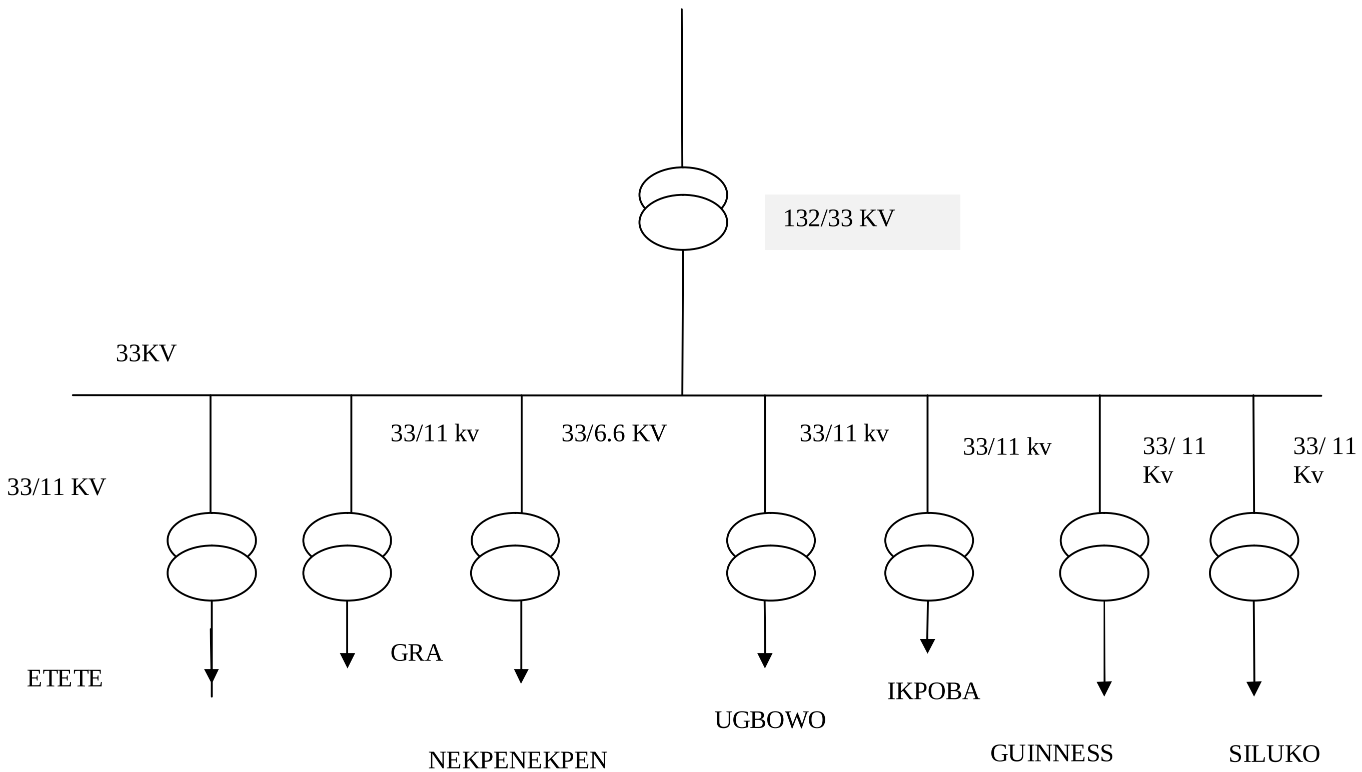

Fig. 1.0 Network diagram for Benin City