Load Survey and Maximum Power Demand of Transformers in Power System Network in Ondo State, Ondo West as a Case Studies

AKINRINMADE AKINKUGBE FEDELIS, IJAROTIMI OLUMIDE
Electrical Electronics Engineering Technology Department, Faculty of Engineering, Rufus Giwa Polytechnic, PMB 1019,Owo,Ondo State, Nigeria.
Akinrinmafidelis@rocketmail.com, ijarotimiolumide@yahoo.com

Abstract
There are number of matrices used to capture the variability of loads, some of them are mainly used in reference to a single end-user and some of them are mainly used in reference to a substation transformer or a specific factor. This paper will examine data like load density, demand factor, load factor, minimum load demand. The paper will critically look into the number of transformer substation under any of the functioning injection substation. Using the above data, the criteria for the stability of the electricity in the area could be carried out. The paper will reveal, the load density, ranges from 0.0003kvA/m^2 to 0.0329kvA/m^2. The load factor ranges from 58.1% to 91.9% and the demand factor that ranges from 1.1% to 4.0%.
Keywords: Load density, Load factor, and Demand factor, Injection Substation, Transformer Substation and Stability.

1. INTRODUTION

Most of the Industrial and Residential layout in Ondo State are experiencing power outage. This is as a result of over-loading of a particular Transformer in an injection substation which resulted to load shedding (Usifo and Paul 2006). This paper will define the following information: Load Density, maximum demand, Demand factor, Load factor, and Diversity factors. These are tools for Engineers (Electrical) to carry out an effective load survey that can minimize future operational problems in substations.

1.1 LOAD FACTOR [L.F]

A ratio of actual energy supplied (in kwh) over a period divided by the maximum demand in KW over that period, multiplied by the time period selected (i. e. actual energy supplied divided by potential energy supplied it is always less or equal to unity (IEEE 2001).

$$L.F = \frac{\text{Actual Energy}}{\text{MD (KVA) X PF X t}} \leq 1.0$$

Maximum Demand (MD) in KW = MD (KVA)x Power Factor

1.1.1 MAXIMUM DEMAND

The highest average electrical demand for a specific period typically 5 to 30min and 60min (are normally used as there are close to the thermal constant of transformer and lines of electrical loads in a substation per day, and express it in VA (IEEE 2001).

1.1.2 DEMAND FACTOR

$$\text{DEMAND FACTOR} = \frac{\text{Maximum demand of a system}}{\text{Total connected load of a system.}}$$

Demand factor is always less than one. The lower the demand factor the less the system capacity required to serve the connected load.

1.1.3 DIVERSITY FACTOR

$$\text{DIVERSITY FACTOR} = \frac{\text{Sum of individual maximum demand}}{\text{Maximum demand on power station}}$$

or

$$\frac{\text{Installed load}}{\text{Running load}}$$

Diversity Factor is usually more than one fig 1. (since the sum of individual maximum demand is greater than Maximum demand). The load is time dependent as well being dependent upon equipment characteristics (Pratt 1990).

Table 1.Diversity factor in distribution network

Element of system	Residential	Commercial	General power	Large industrial
Between individual user	2.00	1.46	1.45	____
Between transformer	1.30	1.30	1.35	1.05
Between Feeders	1.15	1.15	1.15	1.05
From user to transformer	2.00	1.46	1.44	____
From user to feeders	2.60	1.90	1.95	1.15
From user to substation	3.00	2.18	2.24	1.32
From user to generating station	3.09	2.40	2.46	1.45

The diversity factor recognizes that the whole load does not equal to the sum of its parts due to this time inter-dependence (i.e. diverseness)

When the maximum demand of a supply is being assessed it is not sufficient to simply add together the ratings of all electrical equipment that could be connected to that supply. If it is done, a figure some what higher than the true maximum demand will be produced, this is because it is unlikely that all the electrical equipment on a supply will be used simultaneously (USA Department of Energy, 2002). The greater the diversity factor the lesser is the cost of generation of power.

1.1.4 LOAD DIVERSITY: It is the maximum weight that can be safely loaded on a unit area – thus, the total connected load per unit areas of a substation by the existing electrical network, it is express in VA/m^2.

Table 2 Injection Substation and Corresponding Feeders in Ondo State

Items	Substations	Feeders
1	Ilesha Road (Akure)	5 feeders
2	RAC (Akure)	4 feeders
3	Idanre (Akure)	1 feeders
4	Owo	3 feeders
5	Oka (Ondo)	2 feeders
6	Agbogbo oke (ondo)	2 feeders
7	Ikare	Ring main unity(RMU)

In this research, Oka (Ondo) as shown in table 2 was chosen for studies. The table 3 shows the transformer substation under the Oka township feeder

Table 3. Transformer Substations

Location	Power Rating (KVA)
Indi	500 KVA
FFF	300 KVA
Akinsoyinu	300 KVA
Agunbiade	500 KVA
Palm Grove 1	300 KVA
Palm Grove 2	300 KVA
Akinmarin	500 KVA
Okeodunwo	500 KVA
Adeyemi 1	500 KVA
Adeyemi 2	500 KVA
Irewumi	300 KVA
LA	300 KVA

2. Measurement

2.1 Converge Area: The built up area were determine by the distance [length and breath] covered by the substation in a feeder line.

2.1.1 Maximum Load Demand: The maximum demand for 1-hour interval readings was done on a daily basis for continuous 24hours operation. Readings were taken from the KVA meter in the control room at the power House of each station. Readings were carried out for seven working days from Sunday to Saturday when operations were uninterrupted. Load demand performances were stated in table 5 shown below.

1. Average daily load demand $= \frac{\text{Total maximum demand}}{\text{Number of reading}}$
2. Load factor $= \frac{\text{Average Demand}}{\text{Maximum Demand}}$
3. Load Density $= \frac{\text{Maximum load demand}}{\text{Total connected load}}$

The power of load (KVA), coverage area of load (m^2) and load density ($KVA/m^{2)}$ of each of the injection substation were stated in table 2.0 below

Table 4. Statistics of Load in the Seven Injection Substations

ITEM	Substation	Power of load (KVA)	Coverage area of load (m^2)	Load density (KVA/m^2)
1	Ilesha Road (akure)	48900	2260040	0.0216
2	Rac Akure	30010	63084015	0.0005
3	Idanre (Akure)	20144	40152030	0.0005
4	Owo (Owo)	30700	50380400	0.0006
5	Oka (Ondo)	40400	17080680	0.0024
6	Agbogbo Oke (Ondo)	40800	7464114	0.0055
7	RMU (Ikare)	320400	17306060	0.0019
Total	Total	531354	197727339	0.033

Average of power load $= \frac{531335}{7} = 75907.71KVA$

Average area of load $= \frac{197727339}{7} = 28,246,763.71m^2$

Average load density $= \frac{0.033}{7} = 0.0047KVA/m^2$

Table 6. Oka (Ondo) injection substation load demand performances

		05/04/13	06/04/13	07/04/13	08/04/13	09/04/13	10/04/13	11/04/13
		SUN	MON	TUE	WED	THUR	FRI	SAT
	Time	Power KVA	Power KVA	Power KVA	Power KVA	Power KVA	Power KVA	Power KVA
1	6.AM	548	480	540	440	504	510	560
2	7.00	548	480	540	440	504	516	560
3	8.00	548	480	540	440	504	516	560
4	9.00	548	480	540	440	504	516	560
5	10.00	548	480	540	440	504	516	560
6	11.00	570	570	540	440	516	560	570
7	12.PM	570	570	540	470	560	564	570
8	1.00	570	580	552	500	560	518	550
9	2.00	440	470	480	460	560	516	550
10	3.00	440	470	480	460	560	480	510
11	4.00	440	470	480	460	560	480	440
12	5.00	440	470	480	460	560	480	440
13	6.PM	444	444	368	460	560	480	490
14	7.00	444	444	480	460	560	480	490
15	8.00	000	444	480	460	470	500	490
16	9.00	468	444	480	460	500	500	490
17	10.00	492	444	470	460	480	450	480
18	11.00	540	452	470	628	564	450	480
19	12AM	540	570	570	636	648	640	630
20	1.00	540	000	640	624	648	680	660
21	2.00	540	600	640	600	636	680	660
22	3.00	630	600	620	576	564	680	590
23	4.00	630	600	580	576	564	680	590
24	5.00	630	560	560	554	516	600	590
25	Total	12,108	11,602	12,610	11994	13106	12992	13070
26	Average	504.5	483.4	525.4	499.8	546.1	541.3	544.6
27	Max. Demand Power for 30min	630	600	640	628	648	680	660660
28	Load factor	0.800	0.806	0.821	0.796	0.843	0.796	0.825
29	Total load connected	40400	40400	40400	40400	40400	40400	40400
30	Demand factor	0.016	0.015	0.016	0.016	0.016	0.017	0.016

This table reveals that the highest maximum demand is 680KVA, having the load factor of 0.796 and demand

factor of 0.017 for 10/04/2013, as equally depleted in Figure 1.
During the field work of the load demand monitoring, the entire Ondo West local Government could not be fully energised at the same time. It was shown that the load demand was higher than the transformer ratings of each of the injection transformer substations. Then load shedding comes to existence. Also the four feeders in Ondo West can not be picked at the same time. it is either they pick College feeder in (AGBOGBO OKE) and OKA township feeder at the same time or they pick YABA township feeder and AWOYAYA feeder. Before the end of the study it was discovered that the AWOYAYA feeder has packed up and all the transformer sub-stations under its usage has been diverted to OKA township feeder. The OKA township feeder is now experiencing a lot of overload.

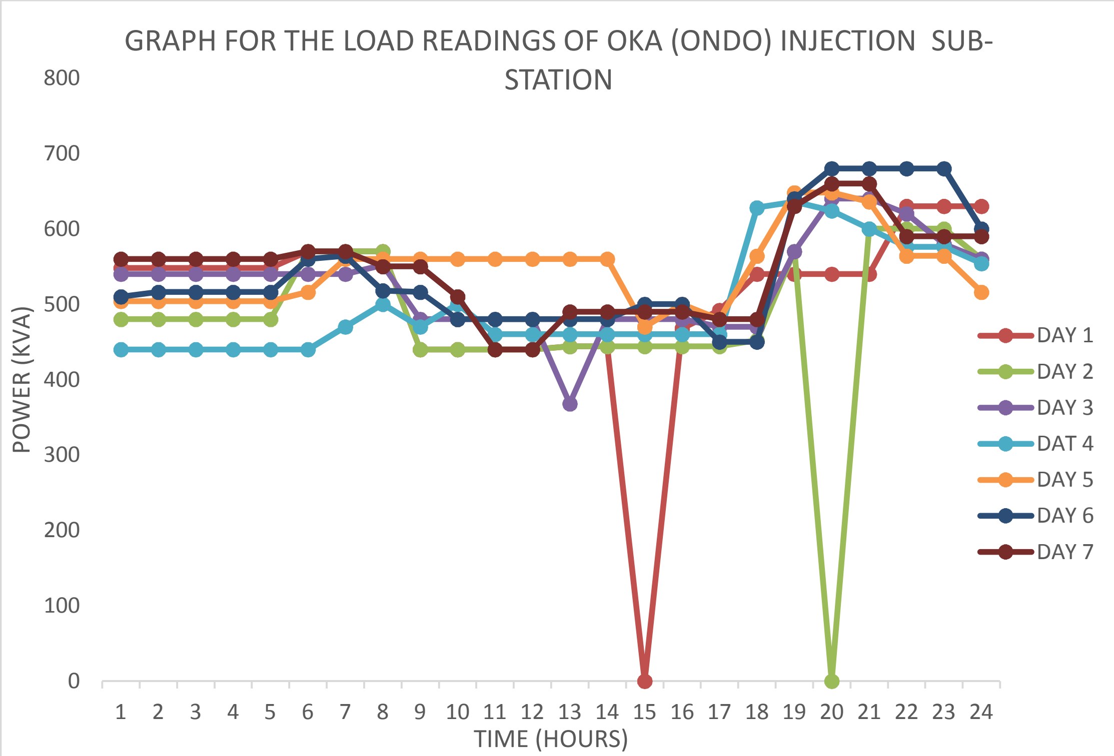

Figure 1. Hourly Load Demand for 7 Days in Oka (Ondo) Injection Sub-Station

This paper will now link us with power generation status as shown in the Table below:

Table7. Existing govt. Owned power stations – Hydro (CBN 2009)

S/NO	Name of power generating Company	Year of Const.	Location	Installed Capacity (MW)	Available Capacity (MW)
1	Kainji/jebba Hydroelectric plc – Kainji Power Station	1968	Kainji, Niger State	760	480
2	Kainji/jebba Hydroelectric plc – Jebba Power Station	1985	Jebba, Niger State	540	450
3	Shiroro Hydroelectric plc	1989	Shiroro, Niger state, Nigeria	600	450
		TOTAL		1,900	1,380

Table 8. Existing Federal government owned Power Stations – Thermal: (CBN 2009)

S/NO	Name of Generation Company	Year of Const.	Location	Installed Capacity (MW)	Available Capacity (MW)
1	Egbin Power PLC	1986	Egbin, Lagos State	1320	1100
2	Geregu Power PLC	2007	Geregu, Kogi State	414	276
3	Omotosho Power PLC	2007	Omotosho, Ondo State.	304	76
4	Olorunsogo power PLC	2008	Olorunsogo, Ogun State	304	76
5	Olorunsogo power PLC	1966	Ughelli, Delta State	900	300
6	Sapele Power PLC	1978	Sapele, Delta State	1020	90
7	Afam(Iv-V)Power PLC	1963/01	Afam, Rivers State,	726	60
8	Calabar thermal Power station	1934	Calabar, Cross River State	6.6	Nil
9	Oji River Power Station	1956	Oji River, Achi, Enugu State	10	Nil
		Total		5,004.6	1,978

Table 9. Independent Power Projects that are non-Federal Government of Nigeria funded investment in the Nigerian power generation industry (CBN 2009)

S/No	NAME OF POWER PLANT	Location	Installed Capacity (Mw)	Available Capacity (Mw)
1	AES POWER STATION	Egbin, Lagos State	224	224
2	SHELL- AFAM VI POWER STATION	Afam, Rivers State	650	650
3	AGIP – OKPAI POWER STATION	Okpai, Delta State	480	480
4	ASG- IBOM POWER STATION	Akwa Ibom State	155	76
5	RSG- TRANS AMADI POWER STATION	Port Harcourt, Rivers State	100	24
6	RSG- OMOKU POWER STATION	Omoku, Rivers State	150	30
	Total		1,759	1,484

3. CONCLUSION

The load density, demand factor, and load factor have been established for the selected seven injections substation in Ondo State These factors shall be very useful to practicing engineers (Electrical) in the design; installation, maintenance and operation of transformer in injection substation of a standard control Power House.

4.RECOMMENDATION

- The existing government owned power stations in Nigeria should generate to its full capacity instead of generating lesser than the installed capacity at which they are presently generating**.**

The power holding company should move out of their present plan that is not yielding much result to the next plan. Normally it is not economically feasible to implement the master plan immediately. The objective is to delay capital expenditure for as long as possible to reduce life cycle costs, while maintaining an acceptable quantity of supply.

Master plan layout refers to the long- range plan for the area (based on the expected loading after 20 years, using the optimised technology. The objective of master planning is to ensure upgradeability and optimised long term infrastructure development.

- Nigeria is a developing country, that can adopt the following planning steps (Markku 2008); Evaluate load density distribution, Define planning criteria, Select transformer rating, Select network and substation structure and Select standard Equipment
- A suitable planning loop should be device, first, planning of the first developmental step assuming 2013. Secondly, planning of intermediate network to take effect from 2010. Forecast of area and local development and long term planning stage for 2026 onward.
- The staff in the control room of the power house should be train on the selection of voltage level. Considering a typical voltage level with a power factor of 0.9 as shown in TABLE 10, indicating the selection of a load of 583A of a quarter on 33KV line

Table 10. Voltage level at various loads

	Typical Power Demand	400V	11KV	33KV	132KV	220KV	400kv
Lamp	100w	0.16A	0.006	0.003	0.0005	0.0003	0.0002
House	5KW	8A	0.3	0.15	0.02	0.015	0.008
Quarter	20Mw	32075	1166A	583A	97	58	32
City	500Mw	801875	29159	14580	2430A	1458A	802
District/country	2Gw	3207501	116636	58318	9720	5832	3207A

Field work at Oka Ondo control room (2013)

- Power Holding company should avoid over-long projection of lines on a particular feeder. The company should involve in development of several feeders as shown in figure 2 below (Christopher 2010). To avoid overloading of the transformer in an injection substation.

TRANSMISSION AND DISTRIBUTION NETWORKING CONCEPT

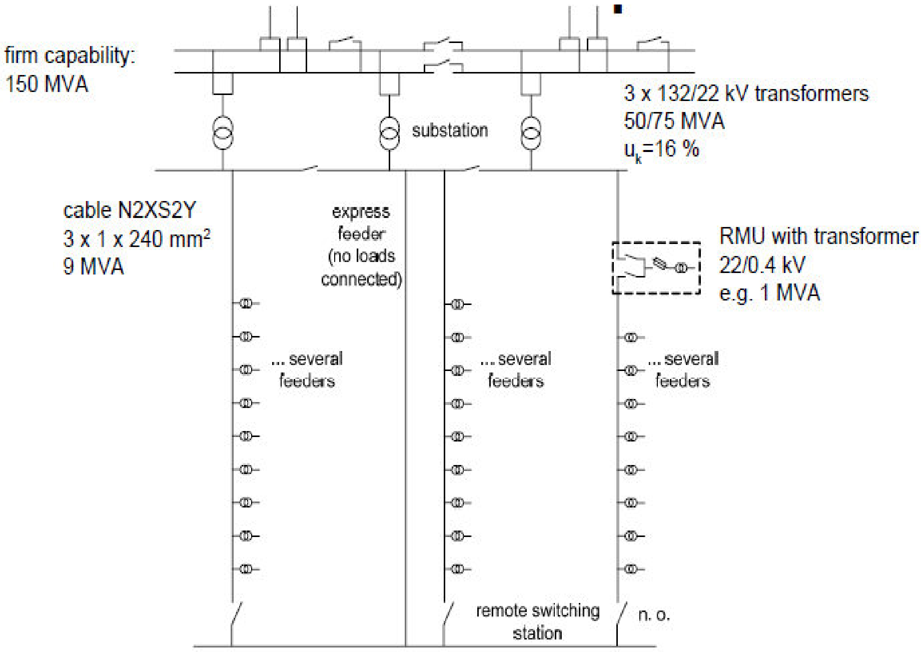

Figure 2 Networking Concept

- **Determination of Transformer Peak Responsibility Factor (PRF)**

The transformer PRF is the square of the ratio of the transformer load at the time of the customer peak load to the transformer peak load. The PRF of a load depends on how well the load is correlated with the system load; it also depends on the load factor (LF). A load with a LF close to 1 is likely to also have a PRF close to 1 (Pratt 1990). The Power holding company should endeavour to estimate the distribution of PRF as a function of LF from available hourly load data in each of the injection substation.

- Table 7. reveal that the existing Government owns power generating stations are not pumping power to national Grid up to the installed capacity.

Also Table 8. shows that most the thermal power stations were shutdown and some are not generating power up to their installed capacity.

Finally, Table 9. reveals that three out of six private owned power generating stations are effective while other four are not generating power up to their installed capacity. This proves that all our power generating stations are under-utilised. It is advisable that Nigeria power holding company should be fully privatised.

REFERENCES

Christopher Prévé (2010): Protection of Electrical Network, New Delhi pg 1277-1278

Markku Hyvärinen (2008): Electrical networks and economies of load Density Helsinki University of Technology, Helsinki. Pg 104-103.

Pratt, R. G (1990): *Commercial Equipment Loads: End-Use Load and ConsumerAssessmentProgram(ELCAP),*Pacific s Northwest Laboratory Prepared for the Bonneville Power Administration. Report No. DOE/BP-13795-24.

USA Department of Energy (2002) - U.S. Federal Energy Regulator Commission, *Form No. 714* - http://www.ferc.gov/ELECTRIC/F714/DATA/F714data.htm.
IEEE (2001), *Draft Guide for Distribution Transformer Loss Evaluation,*. 345 East 47th Street, New York, NY.
Usifo O. and Paul O. (2006) Formulation of average permissible radial distance between a distribution sub-station and residential electricity consumers in Nigeria. International conference and exhibition on power and Telecommunications pg 06-11
CBN (2009) National Integrated Power Projects, Central Bank of Nigeria Annual Report, Abuja.

First Author (Engineer Akinrinmade Akinkugbe Fidelis)
BORN AT ONDO IN ONDO STATE IN 1968 JOINED PRIMARY SCHOOL IN 1976 TO 1981. ENROLLED IN SECONDARY SCHOOL EDUCATION IN 1981 TO 1986. OBTAINED (ND)NATIONAL DIPLOMA AND (B.ENG) BACHELOR OF ENGINEERING IN ONDO STATE POLYTECHNIC OWO (1991) AND IN ENUGU STATE UNIVERSITY OF SCIENCE AND TECHNOLOGY ENUGU (1996) RESPECTIVELY. COPORATE MEMBER OF NIGERIAN SOCIETY OF ENGINEERS (MNSE 2007) COUNCIL OF REGISTERED ENGINEER (ELECTRICAL COREN 2009) CURRENTLY M.SC STUDENT IN PHYSICS ELECTRONICS IN INSTRUMENTATION OPTION AT ADEKUNLE AJASIN UNIVERSITY AKUNGBA AKOKO ONDO STATE. Currently an Academic Staff of Rufus Giwa Polytechnic Owo, Ondo State Nigeria.
Area of interest Research on Fuel less Generator using D.C Motors, Alternators, automatic voltage regulator and Highly Rated deep cycle batteries for power generations

SECOND AUTHOR
BORN AT OWO IN ONDO STATE IN 1971 OBTAINED HND IN ELECTRONICS ENGINEERING FROM THE POLYTECHNIC IBADAN OYO STATE. OBTAINED M.SC IN ELECTRONIC COMMUNICATION AND COMPUTER ENGINEERING IN 2012 FROM NOTTINGHAM UNIVERSITY. Lecturer 1 at Rufus Giwa Polytechnic Owo Ondo State Nigeria.
Areas of interest are Wireless Communication and Antenna