Evaluation of Electric Power Supply to Staff Residential Quarters in Ahmadu Bello University Main Campus, Zaria

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Received: 20/8/2019 **Reviewed: 25/11/2019** **Accepted: 13/6/2020**

Power supply remains an important factor for socio-economic and technological development of every nation. Despite this reality, most countries especially from the developing world have not been able to solve the problem of power supply. In Nigeria, power supply has become the most critical factor that has engaged policy debates, yet the problem has not been clearly addressed to ease livelihood. This study analysed; the perception of power quality, implications of poor electric power supply, assess the duration, and solutions to effects of poor electric power supply in Ahmadu Bello University (A. B. U) Zaria, Main Campus Staff Quarters. One hundred (100) questionnaires were distributed to the residents using convenience sampling. Result shows that the duration of power supplied to the quarters experiences interruptions which affects the quality of power. Also, the use of devices has shown to be effective in reducing and/or preventing poor power quality supply. Efforts should also be made by the service provider to ensure that loads are balanced among the phases thereby reducing faults in different phases.

Keywords: Power, supply, quality, steady, performance, consequences and solutions

Introduction

In any power network, the quality of power is very important and researchers have shown interest in the quality of power delivered to electricity consumers (factories, commercial establishments and residences). Power quality entails the availability of supply, frequency of supply, voltage magnitude and waveform characteristics of the supply (Johnson & Hassan, 2016). Therefore, a good power quality could be described as a steady and constant supply of electricity at a steady voltage and frequency, which supports a reliable operation of its loads or the supply of electricity for the equipment or process to operate satisfactorily (Kusko & Thompson, 2007).

Power quality is poor when; the supply is not constant (i.e. outage or interruption); the supplied voltage is lower to or above acceptable range of magnitude; the power system frequency is fluctuating and when the current and voltage sinusoidal waveform of supply is distorted. Therefore, power quality can be defined as the extent of deviation from nominal value of frequency, current and voltage magnitude (Dungan *et al.*, 2012).

Power quality may be described as supplied electricity that allow the smooth operation of equipment and appliances at home, office and industry. According to Dungan *et al.* (2012), Power quality problem from a customer's perspective is any problem manifested in voltage, current or frequency deviations which result in power failure or mis- operation of customer's equipment.

Along with technology advances, the performance of electronic devices is linked to power quality supply. Therefore, equipment design forms a major determinant between good and bad power quality. For instance, some appliances and equipment may not work properly if the voltage is lower or higher than a range of values which may lead to failure or low performance of the appliance (Alam & Gain, 2014). In Nigeria, power failure is what we experience on daily basis and is unreliable (Popoola, Ponnle & Ale, 2011). Power quality issue has become strategic due to its economic necessity for businesses to be highly competitive and the increased usage of equipment that is sensitive to voltage disturbance and/or generates disturbance itself (Ferracci, 2001).

The causes of poor electric power supply from research include one or many of the following; fault clearing or unclear fault, facility fault, large electrical loads, switching off large induction motors and power correction factor capacitor switching. Other causes include; overloaded wiring, sudden load reduction, improper ground technician, open neutral connection and improper installation of the electrical equipment. Causes of poor electric power supply outside the building are; whether condition, human fault (accident), overloaded transformer, switchgear, unbalanced phase loading condition and utility fault on different phase. The consequence of poor power supply within and outside the building includes the following; computer lockup, light flickering, loss of data, process interruption (Johnson & Hassan, 2016; Alam & Gain, 2014).

Literature Review

Electricity supply is one of the key indices used to measure the development status of any country, because the power sector is an engine of economic growth and technological development (United Nation Economic & Social Commission for Asia & the Pacific UNESCAP, 2013). Electric power system comprises of generating station, transmission network and distribution network. They function together to provide adequate power supply from the sources to the end users or customers, which include factories, commercial establishments and residences. The power supplied should be steady and of good quality, but due to some factors of disturbances that occur at different levels of the system, either at the generation, transmission or distribution stage(s), the quality becomes compromised (Oluremi & Able, 2011; Boyi, 2013). Some of the problems that results in poor power quality supply include distance of supply to load centres and utilisation points, variations in demand, use of complex electronic equipment by consumers.

Power Quality Problems and Causes

According to Johnson and Hassan (2016), and Alam and Gain (2014), other related poor power quality issues are identified below.

Very Short Interruption

This refers to the interruption of electrical supply for duration ranging from few milliseconds to one or two seconds. This causes the loss of information, ripping of protection devices and the malfunction of data processing equipment.

Voltage Swell

This is an increase in the nominal supply voltage. The voltage swell usually rises between the range values of 1.1 to 1.8 pu of the normal voltage for duration of half a cycle to several seconds. This phenomenon is usually caused by the faulty conditions at various points in the AC distribution system, turning off heavy loads, badly regulated transformer.

Harmonic Distortion

This causes distortion in the current and voltage waveform of the supply. Factors causing this type of defect include nonlinear electric loads which includes rectifiers, inverter, Uninterrupted Power Supplies (UPS), arc furnace, welder voltage controller, variable drives and frequency converters.

Voltage Unbalance

This is common in a three-phase system in which there is an unequal voltage magnitude between the phases. The causes of this power quality problem include the large loads on single phases, uneven and incorrect distribution of all single phases load of the system.

Voltage Fluctuations

This is caused by arc furnaces, frequent start and stop of electric motors e.g. elevators, change in magnitude of loads. This results in under voltages, flickering of lighting and screens and unsteady visual perception.

Blackouts

This is also known as outage or power failure and is a zero-voltage condition that lasts for more than two cycles. It may be caused by power distribution failure or tripping of a circuit breaker. This could cause data loss or corruption and equipment damage (Dungan *et al.,* 2012).

Brownouts

This is the supply of a low voltage at a steady state. This occurs when the equipment cannot meet the requirements and must lower voltage to limit the maximum power. This causes glitches, data loss, and equipment failure (Dungan *et al.,* 2012).

Long Interruption

This is when the power supply is interrupted for duration greater than one to two seconds and causes equipment to stop working. Factors causing equipment failure in a power system network leading to long interruption include storms, objects striking on power poles, fire, human error, failure of protection devices and bad coordination (Dungan *et al.,* 2012).

Voltage Surges/Spikes

This is the sudden increase in voltage instantly due to spike or over long duration (surge). The voltage is usually higher than 110% above normal. The most common causes are turning off heavy equipment and lighting strikes.

Voltage Sag or Dip

Short duration under voltages are referred to as sags or dips. This is usually a reduction in nominal voltage for short period of time ranging between 0.1 to 0.9 pu of the nominal power supply. The reduction in nominal voltage is followed by a voltage recovery. This is usually caused by starting of electric motor or switching of heavy load, incorrectly set transformer taps and excessive network loading. This causes an indirect over loading problems.

Flicker

This is the rapid visible changes in brightening and dimming of screen and variation in the luminosity produced by light bulb. It occurs as a result of random and repetitive variations in voltage. This is usually caused by switching on/off of electric motor, arc furnaces, wielding and pulsating load.

Some Solutions to Power Quality

Factors that could prevent or reduce power quality problems vary, depending on the stage(s) of the power supply system (generation, distribution and consumption). The methods employed cannot eliminate the problems completely, but reduce its effect drastically.

One of the ways to reduce power quality problems is to ensure adequate power in the grid and power lines to meet the required demand of consumers (Johnson, 2015). This could help mitigate unbalanced voltage. Equipment manufacturer should be aware of power quality problems and design equipment in such a way that the equipment does not contribute to power problems. Proper grounding of electrical system protects the installation of equipment and users as well as enhance better performance of the system (Johnson, 2015).

There are a number of power electronic devices that can be used to regulate, control and mitigate power quality issues. Interfacing devices are employed to interfere between the supply socket and sensitive equipment. These devices prevent power quality problem in the supply from reaching the equipment or at the main consumer electrical service panel. Examples of these are automatic voltage regulator (AVR), UPS, transient voltage surge suppression (TVSS) and dynamic voltage regulator (DVR). Voltage sag and surge are prevented by the use of a device static var compensator (SVC) as well as improve the capability of long transmission line (Almeida *et al*., 2016).

Methodology

The survey was carried out to ascertain the perception of occupants in A. B. U. Zaria Main Campus Staff Quarters, on the duration of electric power supply, the quality of power supply, consequences and possible solutions associated to the quality of power supplied. Staff residential quarters of A. B. U. Zaria Main Campus, form the study area with a population of 1156 houses.

A convenience sampling technique was used to administer 100 questionnaires to occupants of the houses. The occupant's responses were collated and analysed to obtain their perception.

Out of the 100 houses issued the questionnaire for their responses, only 93 questionnaires were collected and utilised for the analysis. The information obtained from users were based on the; level of awareness, quality of power supply, causes and consequences of poor power supply within and outside the building. The data were analysed using statistical mean, standard deviation and ranking.

Results

Both Descriptive and inferential statistical techniques were employed to achieve the objectives of this study. The five (5) Point Likert-type ordinal scale was used to adjudge the general opinion of the respondents with the two (2) scales to agree, a n eutral scale and the other two (2) scales to disagree in order to facilitate inferential test.

Table 1 shows five (5) ranges of hours used to assess the duration of power supplied to the staff quarters. Power supply duration ranked 1st, 2nd, 3rd, and 4th have an average mean of 4.69 with at least 10 hours of supply, and according to Kayode *et al.* (2018), eight hours is the average duration of power supply in Nigeria. Therefore, the power supply in Table 1 ranked from 1st to 4th indicates that the hours of power supplied is above average. The total average mean value 3.95, according to Kusko and Thompson (2007), implies that the power supplied is not steady and constant as such, according to Dungan *et al.* (2012), the disruptions could lead to frequent outages, blackouts and disruptive use of installations by end users, loss of data and light flickering in the University Staff Quarters.

Table 1: Duration of Power Supply

Sn	Power Supply (Hours)	N	Mean	Rank
1	21-23	93	4.74	1
2	18-20	93	4.73	2
3	14-17	93	4.70	3
4	10-13	93	4.60	4
5	0-9	93	1.00	5
		Total Ave. mean	3.95	

(1) Always (2) Often (3) About Half the time (4) Seldom (5) Never

Table 2: Causes of Poor Power Supply Inside the Building

Sn	Causes from within the building	N	Mean	Std. Dev.	Rank
1	Human fault (accident)	93	1.46	0.5012	1
2	Improper ground technician	93	1.46	0.5011	2
3	Improper installation of machine	93	1.45	0.4991	3
4	Unbalanced load in phase	93	1.41	0.4961	4
5	Sudden loads reduction	93	1.36	0.4810	5
6	Open natural connection	93	1.36	0.4809	6
7	Overloaded wiring	93	1.34	0.4776	7
8	Improper surveying of machine/equipment	93	1.33	0.4700	8
9	Power correction factor capacity switching	93	1.17	0.3794	9
10	Switching off the large inductive loads	93	1.16	0.3697	10
11	Facility fault	93	1.16	0.3698	11
12	Large electric loads	93	1.12	0.3370	12
13	Fault clearing	93	1.11	0.3114	13
		Ave. mean	1.21		

(1) Strongly Agree (2) Agree (3) Neutral (4) Disagree (5) Strongly Disagree

Table 2 shows the major causes of poor power supply within the building. The problems ranked from 1st– 7th is associated with human errors and they have mean values ranging from 1.46 to 1.34. These could be associated with power quality problems such as long interruptions; voltage swell and voltage unbalance. Subsequent causes within the building are from the utility, circuit, equipment or systems and ranked low from 8th to 13th with mean values ranging from 1.33 to 1.11. These problems could lead to voltage surges/spikes, and voltage sag or dip. The average mean of 1.21 implies that there are so many problems with the quality of power supplied to the A. B. U. Zaria Main Campus Staff Quarters.

However, the inferential statistic test carried out shows significant differences on the occupants' responses on the causes of poor power quality supply within the buildings as X^2 obtained (4.41) is < X^2 critical (35.55). This implies that the total agreement on the responses and further inquiries should be conducted by means of experimental test to verify the extent of the causes for further improvements.

Table 3, shows utility fault on different phase and unbalanced phase loading condition as the most frequent causes of poor supply being ranked 1st and 2nd with mean values 1.38 and 1.37 respectively. The average mean of 1.29 implies that these could be associated with power quality problems such as long interruption, blackouts and voltage surges/spikes.

Table 4 shows an average mean of 1.28, which could imply that the respondents experience discomfort from some of the appliances and utilities used in their homes. The inferential statistics test shows no significant differences on the responses of the consequences of poor power quality as X^2 obtained (1.63) is < X^2 critical (9.49). This implies there is an adequate similarity on the respondents understanding and frequency of the consequences.

Table 3: Causes of Poor Power Supply outside the Building

Sn	**Causes outside** the **building**	**N**	Mean	**Std. Des.**	**Rank**
1	Utility fault on different phase	93	1.38	0.6064	1
2	Unbalanced phase loading condition	93	1.37	0.6063	2
3	Switchgear	93	1.34	0.5988	3
4	Overloaded transformer	93	1.30	0.5857	4
5	Human fault (accident)	93	1.26	0.5238	5
6	Weather condition	93	1.10	0.2972	6
		Ave. mean	1.29		

(1) Strongly Agree (2) Agree (3) Neutral (4) Disagree (5) Strongly Disagree

Table 4: Consequences of Poor Power Supply on the Equipment

Sn	Consequences on the Equipment	N	Mean	Std. Dev.	Rank
1	Nuisance tripping	93	1.33	0.5959	1
2	Loss of data	93	1.33	0.5958	2
3	Microprocessor controlled error	93	1.31	0.5657	3
4	Light flickering	93	1.28	0.5184	4
5	Computer lockup	93	1.13	0.4228	5
		Ave. mean	1.28		

(1) Strongly Agree (2) Agree (3) Neutral (4) Disagree (5) Strongly Disagree

Table 5: Solutions to Poor Power

Sn	Solution to poor power supply	N	Mean	Rank
1	Dedicated circuit	93	1.43	1
2	Total rewiring	93	1.41	2
3	TN-S rewiring	93	1.38	3
4	Upsized neutral	93	1.33	4
5	Mesh dearth	93	1.31	5
6	Active condition	93	1.26	6
7	Passive filter	93	1.23	7
8	Uninterruptible power supply	93	1.18	8
9	Surge protection	93	1.13	9
10	Equipment de-rating	93	1.10	10
	Ave. Mean		1.28	

(1) Very effective (2) Effective (3) Neutral (4) Ineffective (5) Very Ineffective

Table 5 shows that providing dedicated circuit as the more appropriate solution to problems with total rewiring and TN-S rewiring as effective with mean of 1.41 and 1.38 respectively. Uninterruptible power supply, Surge protection and Equipment de-rating have mean values of 1.18, 1.13 and 1.10 respectively, were also found to be very effective in reducing and/or preventing poor power quality. Table 6 shows the average mean of 1.13, which implies that the use of devices to reduce and/or prevent power quality problems are very effective.

Conclusion

Major causes of poor power supply within the building arise from human errors, the circuits and equipment. Respondents also opined to nuisance tripping and loss of data as the most severe consequences than computer lockup and light flickering, while providing dedicated circuit and total rewiring as the common solutions to power problems within the study area. Based on these, it is recommended that awareness campaign should be mounted to sensitise the occupants on how to use electricity to minimise human error. Efforts should also be made by the service provider to ensure that loads are balanced among the phases thereby reducing faults in different phases.

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