International Journal of Functional Research in Science and Engineering
e-ISSN: 2814-0923
www.ijfrse.com
Volume 1; Issue 2; September 2023; Page No. 60-65.

ELECTRICITY THEFT AND POWER SUPPLY IN EDO STATE, NIGERIA: A CORRELATIONAL ANALYSIS

*** Osadebamwen Keneth Ojo**

[1]Department of Electrical/Electronic, Edo State Polytechnic Usen, Edo State.

Abstract
The availability of electricity in Nigeria has continued to worsen over the years, creating constraints on the country's economic growth. The country has been unable to meet demand because of its policies, regulations, management of operations, and electricity espionage accomplished by unscrupulous persons tapping into the numerous power supply networks. The present study examined the correlation between the trends in energy theft among users and the quality of power supply in Edo state, Nigeria. The study employed a correlational method to ascertain the correlation between energy theft and power supply in Edo state, Nigeria. The study population comprised energy consumers within the residential category established by the BEDC. A random sample of 277 residential consumers and BEDC employees completed the research questionnaires. The finding shows that 31.2% of the energy consumers showed they never participated in energy theft, while 68.8% showed high involvement. A Pearson's product-moment correlation was conducted to determine the correlation between energy theft and power supply quality in Edo state. The result revealed that the relationship is linear, both variables were normally distributed as calculated by Shapiro-Wilk's test ($p > .05$), and there were no outliers. There was a statistically significant, moderate positive correlation between energy theft and power supply quality in Edo state, $r (275) = .41$, $p < .001$. Most importantly, observation of the R^2 revealed that energy theft explained about 11.6% of the variation in power supply quality in Edo state. The outcome offers the government and the electrical authorities helpful information.

Keywords: energy theft, power supply, BEDC, power distribution

Introduction

With an installed capacity of around 12,522 MW, thermal and hydropower comprise most of Nigeria's energy production. The nation is a member of the Economic Community of West African States (ECOWAS) and the West African Power Pool (WAPP), an organization inside ECOWAS with 14 other nations that comprise the regional economic community. WAPP was established to manage power exchange among the ECOWAS member states and promote and build infrastructure for power generation and transmission. Togo, Niger, and the Republic of Benin currently receive electricity from Nigeria.

As part of Nigeria's government effort to restructure the electricity industry and enhance power supply efficiency in the country, about 11 electricity distribution companies (DISCOs) and six generating companies (GENCOs) were privatized in 2013 (Adedeji, 2017) while maintaining complete control of the Transmission Company of Nigeria (TCN). The nation is presently implementing extensive power sector changes to boost capacity, enhance access to electricity, and modernize transmission. The unbundling aimed to make the transition from the government monopoly to the private companies as seamless as feasible. Thus, the transformation in the electricity industry created a competitive electricity market under a unified regulatory body.

Regardless, there is growing concern that the power reforms in Nigeria have not helped the country achieve a sustainable energy balance (Arowolo & Perez, 2020). Unreliable and epileptic power supply has been a significant problem in the nation's development (Jimah et al., 2019). Nigerians generally agree that the nation's energy supply is unreliable and in poor condition and is characterized by low accessibility, epileptic and poor transmission (Ebhota & Tabakov, 2018), thereby affecting the economic development of the nation (Amuta et al., 2018). The Nigerian national grid falls short of providing a reliable electricity supply to consumers due to inadequate generation capacity, limited transmission capacity, and outdated distribution infrastructure. High aggregate technical, commercial, and collections (ATC&C) losses and non-cost-reflective tariffs, including poor policy initiative, non-existent asset protection mechanism, poor maintenance culture, and insufficient gas supply (Amadi, 2015; Emem, 2015; Garba et al., 2014;

Jimah et al., 2019; Nwachukwu, 2014; Ogunyemi & Adetona, 2019; Okafor, 2008; Okorie & Abdu, 2015; Olaosebikan Aremu, 2019; Oluwole et al., 2012) mean that the Nigerian electricity sector is facing many challenges including energy theft.

Energy theft and non-technical losses have far-reaching consequences (Adongo et al., 2021), affecting both power utilities and the wider society (Lin et al., 2021). Power utilities face financial losses that impede their ability to invest in infrastructure, upgrade services, and ensure reliable power supply (Feng et al., 2020). These losses also hinder the utilities' capacity to provide affordable electricity to consumers and impede progress toward universal energy access. Additionally, energy theft creates an uneven playing field, as honest customers bear the burden of subsidizing the losses incurred due to theft and non-payment. Energy theft poses a problem for underdeveloped countries (Arkorful, 2022). Energy theft is a significant issue in many developing countries, including Nigeria. As a result, the country's power firms' ability to produce revenue and distribute power efficiently is harmed.

The menace of energy theft globally has been demonstrated similarly, ranging from meter tampering, illegal connections, billing irregularities, and unpaid bills (Smith, 2004). Although energy theft threatens human, economic, and infrastructural development, it is also a criminal offense (Hardianto & Akbar, 2021). Energy theft entails a non-technical loss (NTL) in transmitting electrical energy that has been difficult for power companies to detect and combat. Thus, the inability of the power companies to sufficiently detect and prevent electricity theft has resulted in an enormous loss of income (Adil et al., 2020; Arango et al., 2017; Arif et al., 2021; Aslam et al., 2020; de Oliveira Ventura et al., 2020; Khan et al., 2020; Khonjelwayo & Nthakheni, 2021; Yakubu et al., 2018) and disruption in power supply (Jain & Bagree, 2011; Lavanya et al., 2020; Naik & Patil, 2020). Indeed, there are indications that energy worth 21 billion is stolen annually in Nigeria (Osigwe, 2018). Directly, the expenses are passed on to the consumers in the form of higher tariff rates; indirectly, the costs are passed on to the customers in the form of lower quality of service.

Theft has been connected to the highly publicized power issue and is relatively prevalent in the electrical distribution systems of several African nations. For instance, Louw and Bokoro (2019) noted that ground surface conduct tampering and electricity theft are widespread issues in South Africa. Accordingly, Kambule and Nwulu (2021) claimed that despite the introduction of prepaid meters in Tanzania and Kenya, problems with power theft, such as meter bypassing and illicit connections, continue to plague the prepaid electricity sectors. Research from Ghana indicates that the two utility companies, the Electricity Company of Ghana (ECG) and the Northern Electricity Distribution Company of the Volta River Authority (NEDco-VRA), deployed prepaid smart energy meters to curb the escalating non-technical losses perpetrated by consumers who take advantage and tamper with meters to hide their actual consumption (Yakubu et al., 2018). There is a growing concern that the failure to combat the trend of electricity theft quickly will throw utility companies into immense debt and trigger more inefficiencies in their operations. Similarly, numerous authors have underscored the trend of electricity theft in Nigeria (Ekere et al., 2019; Josephine & Nathan, 2016; Kambule & Nwulu, 2021; Komolafe & Udofia, 2020; Odje et al., 2021; Ogu et al., 2016; Umar et al., 2022). In many states of Nigeria, including Edo State, the problem of energy theft is underreported.

The Benin Electricity Distribution Company (BEDC) is among the utility distribution companies in Nigeria responsible for electricity distribution in Edo, Delta, Ekiti, and Ondo states. The BEDC maintains an estimated coverage of 55,770 square kilometers. Initially, many of the company's customers were unmetered or had obsolete meters. This was a significant challenge, making energy accountability difficult and encouraging estimated billing, leading to over and under-billing. Consequently, many consumers resorted to various activities relating to electricity theft.

Many people in Edo state still have minimal access to electricity or rely on diesel generators, which are noisy, expensive, and produce localized air pollution because they cannot access reliable grid electricity. However, the report suggests that many households indulge in electricity theft and illegal tampering with electric metering devices (Dike et al., 2015). Observation of the trend of electricity theft in Edo state indicates that electricity tapping was the most common form of energy theft. In a report, the BEDC complained of overwhelming energy theft through meter bypass and tampering. Although energy theft is not unrelated to the growing power inefficiency by the BEDC, the present paper aims to provide a data-driven relationship between energy theft and power supply quality in Edo state.

Cite this article as:
Osadebamwen, K. O. (2023 Electricity Theft and Power Supply in Edo State, Nigeria: A Correlational Analysis. *International Journal of Functional Research in Science & Engineering,1*(2), 60-65.

Method

This study examined the prevalence of electricity theft in Edo, Nigeria, and determined the correlation between energy theft and power supply quality in the state. The study population comprised the BEDC staff and electricity consumers under the residential category of the BEDC. Five towns in Edo state, including Benin City, Usen, Auchi, Igueben, and Ekpoma, were randomly chosen as the study area. However, about three hundred and thirty-two households from the selected towns and the BEDC main office in Benin City were approached between June and August 2023 and asked to participate in the study to ascertain problems related to power distribution in the area. Those who consented (n=312) were given the study questionnaire to fill out on the spot. Consequently, two hundred and seventy-seven (n=277) of the questionnaires distributed were appropriately filled and returned. Thus, they were subjected to further analysis.

Two questionnaires were used in the study. Notably, one questionnaire was designed to ascertain the size of the households' electricity end-users who had been directly involved in the incidence of electricity theft and the effect of electricity theft on power supply in the area using a self-structured questionnaire. The scale was designed to assess the consumer's level of involvement in electricity theft. Statements for the questionnaire were intended to assess the electricity user's previous and present participation in energy-related theft. The statements were empirically selected to test two areas of electricity theft, including meter bypassing and illegal reconnection. The Likert-type scale contains questions ranging from "Can you bypass the meter if you have the opportunity?" to "Have you made any illegal connections." A higher score indicates high electricity theft. The scale recorded a Cronbach alpha of 0.96 following a pilot study.

Data relating to the effect of electricity theft on the efficient power supply was determined by a questionnaire distributed to the thirty-one (n=3) staff of BEDC. Data from the respondents were computed using the statistical package for social science SPSS Version 23. As shown in the table below, a frequency model was used to analyze the prevalence of electricity theft in Edo State, and a Pearson correlation was employed to determine the correlation between energy theft and power supply quality in the study area.

Table 1 shows the distribution of the respondents.

Source	*N*	*m*	*f*
Benin City	73	48	25
Usen	46	30	16
Auchi	43	24	19
Igueben	38	21	17
Ekpoma	46	19	27
BEDC staff	31	19	12
Total	277	161	116

N= Number of participants; M=male; f= females

The table above shows that the majority of the electricity consumers were drawn from Benin City (73), while others were sampled from Usen (46), Auchi (43), Igueben (38), and Ekpoma (46). The table indicates that 161 samples were male, while 116 represented females.

Result

The data retrieved from the respondents were computed with the statistical package for social sciences (SPSS version 23) and analyzed in the table below.

Table 2 shows the frequency of electricity theft in Edo State

Response	N	%
No	62	31.2
Yes	184	68.8
Total	246	100

The table above shows the frequency score of the respondents on electricity theft in Edo State. The result indicates the prevalence of electricity theft in Edo State. The table shows that 31.2% of the respondents indicated they never participated in energy theft, while 68.8% showed high involvement.

Cite this article as:
Osadebamwen, K. O. (2023 Electricity Theft and Power Supply in Edo State, Nigeria: A Correlational Analysis. *International Journal of Functional Research in Science & Engineering,1*(2), 60-65.

A Pearson's product-moment correlation was conducted to determine the correlation between energy theft and power supply quality in Edo state. The result revealed that the relationship is linear, both variables were normally distributed as calculated by Shapiro-Wilk's test ($p > .05$), and there were no outliers. There was a statistically significant, moderate positive correlation between energy theft and power supply quality in Edo state, $r (275) = .41$, $p < .001$. Most importantly, observation of the R^2 revealed that energy theft explained about 11.6% of the variation in power supply quality in Edo state.

Table 3 shows the correlation between the main variables

Variables	*M*	*SD*	*1*	*2*
1, ET	3.17	0.37	.12**	
2, PS	4.61	0.46	.33	.41**
R^2	116			

Note. N = 277, ** = $p < .01$ (two-tailed). ET= Energy theft; PS = Power supply.

Discussion

The current study examined the correlation between energy theft and power supply in Edo State, Nigeria. Two hundred and seventy-seven electricity end-users in selected areas of the state participated in the study. The finding suggested that a significant amount of energy theft occurred (68%). In addition, Pearson's product-moment correlation was performed to determine the correlation between energy theft and power supply quality in Edo state. The result revealed that the relationship is linear, both variables were normally distributed as calculated by Shapiro-Wilk's test ($p > .05$), and there were no outliers. There was a statistically significant, moderate positive correlation between energy theft and power supply quality in Edo state, $r (275) = .41$, $p < .001$. Most importantly, observation of the R^2 revealed that energy theft explained about 11.6% of the variation in power supply quality in Edo state. Consequently, the result indicated the widespread nature of electricity theft in the state, particularly in Benin City, Usen, Auchi, Igueben, and Ekpoma. As expected, the present finding indicates that persistent breach in the electricity infrastructure contributes significantly to the poor power supply in the state. The finding is aligned with previous studies (Gbolahan, 2017; Inhim, 2023; Olufajo et al., 2021). For example, Ghadiali et al. (2022) noted that energy theft affects the proficient power supply and increases the power generating station demand. Several types of energy sabotage are linked to issues like poor power quality, network infrastructure challenges (overloading of the transmission line, feeders, and transformer), fire, load shedding/grid energy insufficiency and instability, equipment failure/damages, irregular supply, and numerous faults in the electricity distribution lines. Therefore, it would appear that the electricity consumers engaging in energy theft contribute to the increasing inefficiencies in power supply. Thus, the finding provides insight into the lack of awareness relative to the consequences of electricity theft among consumers in Edo state.

Conclusion

The present paper provides insight into the level of energy theft in the study area and the resultant effect on the ability of the Benin Electricity Distribution Company to provide electricity to its coverage adequately. The result found a significant percentage of energy theft among energy users in the state. Also, a correlation was established between energy theft and power supply efficiency. It can be concluded that energy theft is a crucially crucial predictive variable in the incompetence and ineffectiveness of the BEDC. Because of the limited sample size and the similarity of the participants, it is essential to exercise extreme caution before generalizing the findings of the current research. Despite the constraints imposed by reality, the current research is an essential first step toward gaining a deeper comprehension of the problem of electricity theft by providing an in-depth analysis of the gravity of the situation in the state. As a result, the finding broadens our knowledge regarding the poor information that energy consumers have concerning the dangers of stealing electricity. The fact that no previous research has made an effort to explore the frequency of energy theft in Edo state is another factor that lends credence to the need for the present investigation. In subsequent studies, investigators ought to utilize data from a more comprehensive source.

References

Adil, M., Javaid, N., Qasim, U., Ullah, I., Shafiq, M., & Choi, J. G. (2020). LSTM and bat-based us boost approach for electricity theft detection. *Applied Sciences (Switzerland)*, *10*(12). https://doi.org/10.3390/app10124378

Amadi, H. N. (2015). Power Outages in Port Harcourt City: Problems and Solutions. *IOSR Journal of Electrical and Electronics Engineering Ver. III*, *10*(2). https://doi.org/10.9790/1676-10235966

Amuta E., Wara S. T., Agbetuyi F., M. S. (2018). Smart Grid Technology Potentials in Nigeria: An Overview.

International Journal of Applied Engineering Research, *32(2)*(ISSN 0973-4562).

Arango, L. G., Deccache, E., Bonatto, B. D., Arango, H., & Pamplona, E. O. (2017). Study of how electricity theft affects the economy of a company that is regulated. *Journal of Control, Automation and Electrical Systems*, *28*(4). https://doi.org/10.1007/s40313-017-0325-z

Arif, A., Javaid, N., Aldegheishem, A., & Alrajeh, N. (2021). Big data analytics for spotting electricity theft in microgrids for smart communities using machine learning techniques. *Concurrency and Computation: Practice and Experience*, *33*(17). https://doi.org/10.1002/cpe.6316

Arowolo, W., & Perez, Y. (2020). Market reform in the Nigeria power sector: A review of the issues and potential solutions. *Energy Policy*, *144*. https://doi.org/10.1016/j.enpol.2020.111580

Aslam, Z., Ahmed, F., Almorgen, A., Shafiq, M., Zuair, M., & Javaid, N. (2020). An Attention Guided Semi-supervised Learning Mechanism to Detect Electricity Frauds in the Distribution Systems. *IEEE Access*. https://doi.org/10.1109/ACCESS.2020.3042636

de Oliveira Ventura, L., Melo, J. D., Padilha-Feltrin, A., Fernández-Gutiérrez, J. P., Sánchez Zuleta, C. C., & Piedrahita Escobar, C. C. (2020). A new way for comparing solutions to non-technical electricity losses in South America. *Utilities Policy*, *67*. https://doi.org/10.1016/j.jup.2020.101113

Dike, D. O., Obiora, U. A., Nwokorie, E. C., & Dike, B. C. (2015). Using a GSM-Based Prepaid Meter to Reduce Household Electricity Theft in Nigeria American Journal of Engineering Research (AJER). *American Journal of Engineering Research (AJER)*, *4*(1).

Ebhota, W. S., & Tabakov, P. Y. (2018). Power Inadequacy, the Thorn in Economic Growth of Nigeria. In *International Journal of Applied Engineering Research* (Vol. 13).

Ekere, J. N., Akor, P. U., & Akor, S. O. (2019). The use of ICT for security and theft prevention in two university libraries in Nigeria. *Library Philosophy and Practice*, *2019*.

Emem, O. (2015). The Energy Crisis in Nigeria and the Role of Law in Promoting Renewable Energy Development. *SSRN Electronic Journal*. https://doi.org/10.2139/ssrn.2672625

Garba, A., Zubairu, T., & Ryal-Net, M. B. (2014). Nigeria Electricity Crisis Rescue Platform: Renewable Energy Technologies Option. *International Journal in Advanced Research in Social Engineering and Development Strategies*, *2*(1).

Gbolahan Olaoluwa, O. (2017). Electricity Theft and Power Quality in Nigeria. *International Journal of Engineering Research & Technology*, *6*.

Ghadiali, S., Zaveri, N., & Ghadiali, Z. (2022). Review of "Detection and Prevention of Electrical Power Theft by Artificial Intelligence and Machine Learning." *13th International Conference on Advances in Computing, Control, and Telecommunication Technologies, ACT 2022*, *8*.

Hardianto, H., & Akbar, A. (2021). Study the Form of Electricity Theft in Area X. *International Journal of Multi-Discipline Science (IJ-MDS)*, *4*(2). https://doi.org/10.26737/ij-mds.v4i2.2738

Inhim Ogbe, B. (2023). Electricity consumers and electricity theft in Edo State, Nigeria: implication for efficient power distribution. *Journal of Advance Research in Electrical & Electronics Engineering (ISSN: 2208-2395)*, *9*(3). https://doi.org/10.53555/nneee.v9i3.1579

Jain, A., & Bagree, M. (2011). A prepaid meter using mobile communication. *International Journal of Engineering, Science and Technology*, *3*(3). https://doi.org/10.4314/ijest.v3i3.68432

Jimah, K. Q., Isah, A. W., & Okundamiya, M. S. (2019). Erratic and Epileptic Power Supply in Nigeria: Causes and Solutions. *Advances in Electrical and Telecommunication Engineering (AETE) ISSN: 2636-7416*, *2*(1).

Josephine, M. M., & Nathan, D. (2016). Curtailing energy theft by remote monitoring case study: University of Nigeria, Nsukka. *Lecture Notes in Engineering and Computer Science*, *2225*.

Kambule, N., & Nwulu, N. (2021). Rationale Part II: A Misdiagnosis of Non-payment and Electricity Theft. In *Lecture Notes in Electrical Engineering* (Vol. 759). https://doi.org/10.1007/978-3-030-71217-4_3

Khan, Z. A., Adil, M., Javaid, N., Saqib, M. N., Shafiq, M., & Choi, J. G. (2020). Detection of electricity theft by supervised learning algorithms applied to smart meter data. *Sustainability (Switzerland)*, *12*(19). https://doi.org/10.3390/su12198023

Khonjelwayo, B., & Nthakheni, T. (2021). Determining the causes of energy losses and the management's role in reducing them: A case study of the City of Tshwane Metropolitan Municipality, South Africa. *Journal of Energy in Southern Africa*, *32*(4). https://doi.org/10.17159/2413-3051/2021/v32i4a8704

Komolafe, O. M., & Udofia, K. M. (2020). Review of electrical energy losses in Nigeria. *Nigerian Journal of Technology*, *39*(1). https://doi.org/10.4314/njt.v39i1.28

Lavanya, S., Arunmozhi, R., Ramesh, B., & Thulasi Yammal, C. (2020). Electricity theft and transmission losses in India. *Journal of Advanced Research in Dynamical and Control Systems*, *12*(2).

https://doi.org/10.5373/JARDCS/V12I2/S20201249

Naik, S., & Patil, S. (2020). Smart electricity measuring system. *2020 International Conference for Emerging Technology, INCET 2020*. https://doi.org/10.1109/INCET49848.2020.9153974

Nwachukwu, M. U. (2014). Determining the causes of energy losses and the management's role in reducing them: A case study of the City of Tshwane Metropolitan Municipality, South Africa. *ISSN*, *4*(3).

Odje, M., Uhunmwangho, R., & Okedu, K. E. (2021). Determining the causes of energy losses and the management's role in reducing them: A case study of the City of Tshwane Metropolitan Municipality, South Africa. *Frontiers in Energy Research*, *9*. https://doi.org/10.3389/fenrg.2021.703265

Ogu, R. E., Chukwudebe, G. A., & Ezenugu, I. A. (2016). An IoT-Based Tamper Prevention System for Electricity Meter. *American Journal of Engineering Research (AJER)*, *5*.

Ogunyemi, J., & Adetona, Z. A. (2019). Power Quality Survey of Voltage Stabilizers and Uninterruptible Power Supply With Nonlinear Loads. *European Journal of Electrical Engineering and Computer Science*, *3*(6). https://doi.org/10.24018/ejece.2019.3.6.141

Okafor, E. E. (2008). Development Crisis of Power Supply and Implications for Industrial Sector in Nigeria. *Studies of Tribes and Tribals*, *6*(2). https://doi.org/10.1080/0972639x.2008.11886580

Okorie, P. U., & Abdu, A. I. (2015). Reliability Evaluation of Power Distribution Network System in Kano Metropolis of Nigeria. *International Journal of Electrical and Electronic Science*, *2*(1).

Olaosebikan Aremu, J. (2019). Epileptic Electric Power Generation and Supply in Nigeria: Causes, Impact and Solution. *Journal of Contemporary Research in Social Sciences*, *1*(3). https://doi.org/10.33094/26410249.2019.13.73.81

Olufajo, O., Ogundipe, A., Atanda, T., & Fakolujo, O. (2021). Sustainable Smart Power Outlet Controller with Online Energy Management System for Public Charging Stations. *SSRG International Journal of Electrical and Electronics Engineering*, *8*(5). https://doi.org/10.14445/23488379/IJEEE-V8I5P104

Oluwole, A., Samuel, O., Festus, O., Olatunji, O., & Polytechnic, R. G. (2012). Electrical power outage in Nigeria : History, causes and possible solutions. *Journal of Energy Technologies and Policy*, *2*(6).

Osigwe, A. (2018). Electricity Theft in Nigeria : How Effective Are the Existing Laws ? *Journal of Energy Technologies and Policy*, *8*(8).

Smith, T. B. (2004). Electricity theft: A comparative analysis. *Energy Policy*, *32*(18). https://doi.org/10.1016/S0301-4215(03)00182-4

Umar, H. A., Fonkam, M., & Prasad, R. (2022). Towards the sustainability of power utilities in Nigeria: a Bayesian network approach. *International Journal of Information Technology (Singapore)*, *14*(3). https://doi.org/10.1007/s41870-022-00876-2

Yakubu, O., Babu C., N., & Adjei, O. (2018). Electricity theft: Analysis of the underlying contributory factors in Ghana. *Energy Policy*, *123*. https://doi.org/10.1016/j.enpol.2018.09.019