

Impact of Energy Access on the Delivery of Construction Projects in Lagos Metropolis, Nigeria

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Abstract:

The construction industry in Nigeria lacks sufficient clean energy resources, which is a basic requirement for sustainable development. Thus, it is important to assess the impacts of energy access on construction projects delivery in Lagos Metropolis, Nigeria. In light of this, research data were collected through questionnaires from the small, medium, and large construction companies in Lagos Metropolis, Nigeria. Data collected were analysed using both descriptive (frequency distribution and mean score ranking) and inferential statistics (Kruskal-Wallis test). The study revealed that the most significant impact of energy access on construction project delivery is increased productivity. Others are fast delivery of construction projects, improved effectiveness of project delivery, reduced stress of manual labour and saves cost overtime. Thus, this study serves as one of the earliest studies that contribute to the body of knowledge on impacts of energy access on construction project delivery.

Keywords: Access, construction, delivery, energy, Nigeria

1 Introduction

The United Nations Sustainable Development Goals (SDGs) 2015 brought to fore the importance of energy to development. The Sustainable Development Goal 7 (SDG 7): affordable and clean energy for all is the fulcrum for achieving other sustainable goals (Barron and Torero, 2017). In 2019, 770 million people lacked access to electricity globally. However, 75% of the population without energy access live in sub-Saharan Africa (IEA, 2020). In 2013, the number of people without access to electricity access in Africa peaked at 610 million but there was a progressive decline to around 580 million in 2019. This is because countries like Kenya, Senegal, Rwanda, Ghana, and Ethiopia made significant access growth. In 2019, the energy access rate in Kenya increased from the previous 20% in 2013 to almost 85% (IEA, 2019).

World primary energy consumption increases by a 10-year average rate of 1.6% per year. In 2018, it increased by 2.8%, whereas a 1.6% increase was recorded in 2019. North America, Europe, and the Commonwealth of Independent States (CIS) all recorded a dip in primary energy consumption while it was below average in South and Central America. There was no significant change in the consumption progression in Africa, Middle East, and Asia in comparison with previous years (Primary energy, 2020). U.S. Energy Information Administration (2020) reported that in 2017, about 1.5 quadrillion British thermal units of primary energy were consumed in Nigeria. Natural gas, petroleum and other liquids accounted for 97% of the total consumption while traditional biomass and waste (wood, charcoal, manure, and crop residues), coal, and renewables accounted for only a small amount of consumption (3%) in 2017.

The construction industry is responsible for the consumption of renewable and non-renewable resources. It is ranked as one of the largest consumers (Horvath, 2004; Holtzhausen, 2007; Dixit et al., 2010). The energy consumed by buildings globally is approximately 50%. (Tennakoon et al., 2019). Energy consumption during the life cycle of a building can be divided into three phases: embodied, operational, and decommissioning energy (Himpe et al., 2012). Embodied energy is consumed at the initial construction of a building and during building maintenance. It is the energy consumed during raw materials extraction, processing and manufacturing of construction materials and building components, transportation and installation of building materials and components, maintenance, and repair of a building (Kassim & Santhi, 2016). Operational energy is the energy required for heating, cooling, ventilation, lighting, equipment, and appliances. Decommissioning energy is the energy consumed in the process of demolishing a building and carting away the remains to a landfill or recycling center.

Nigeria is a country in sub-Saharan Africa. It is rich in the deposition of natural energy resources both renewables and non-renewables and has the 7th largest natural gas reserve globally. The economy of the country is dependent on crude oil which positions it among the top exporters of crude oil. However, there is minimal efficient utilisation of these resources, thus increasing energy poverty in the nation (Oseni, 2012). Over the last 20 years, there has been an upsurge in population growth, resulting in increased demand for modern energy needs.

Most of the secondary energy used in Nigeria is imported, basically due to a lack of functioning refineries in the country to convert the abundant primary energy from its crude state into a finished product (IEA, 2010). Studies have been carried out globally on the impacts of energy access (Barnes, 2014; Bhandari, 2007; Guye, 2017; Matt, 2017; Muawya & Walter, 2012; Olanrele et al., 2020; Tarun et al., 2013; Trace, 2016; Sovacool, 2014, Wagner, 2017). However, these studies have only concentrated on the impacts of energy access on health, education, and development in its broad sense. They failed to study the impacts of energy access on construction objectively. Thus, the need for this study. In light of the foregoing and the reliance of construction activities on energy supply, this study aims to assess the impacts of energy access on the delivery of construction projects in Lagos Metropolis, Nigeria. Construction drives the socio-economic development of a nation, and construction activities heavily depend on energy availability. Thus, this study brings to fore the benefits of energy access for construction activities so that the Nigerian government may be aware of these and in turn make policies that will aid efficient generation and access to energy for construction activities.

2 Energy in construction activities

Energy is the power generated when physical or chemical resources are utilised to provide light, heat, or work machines. (Energy, n.d.). Energy can be divided into two forms, primary and secondary energy. Primary energy is the energy found in nature i.e., energy in its unprocessed or raw form. It includes crude oil, hydropower, sunlight, wind, coal, and nuclear energy (Dixit et al., 2010; Dixit et al., 2014). A building consumes primary energy in two ways: direct consumption through delivered energy sources such as electricity and gasoline; indirect consumption through the use of construction materials (energy used in extraction and processing of raw materials, transportation, and assemblage of components) (Dixit, 2016; Monteiro et al., 2016). Secondary energy is the energy generated from the conversion of primary energy. It includes electricity, gasoline, heat, liquid fuel, and refined biofuel (Resourcefulness, n. d.). Fog et al. (1983) submitted that the activities responsible for energy

consumption on a construction site are transportation, demolition, levelling, earthworks, lifting, compacting and mixing. Table 1 shows the classification of plant, tool, or equipment used in construction, type of energy used, and the construction process in which it is used.

Table 1: Classification of Plants, Tools and Equipment and Energy Used

Plant, tool or equipment	Energy Used	Construction Process
Placers rebators and routers	Electricity	Grooving, moulding and other joinery
Saws	Electricity, compressed air, petrol	Cutting, grinding
Rotary drill, rock drill, picks and breakers	Electricity, compressed air, petrol	Drilling, driving screw
Hammers	Electricity, compressed air, petrol	Hammering
Vibrator	Electricity, compressed air, petrol	Vibrating concrete
Forklift	Diesel	Transporting concrete
Elevators	Petrol or diesel	Hoisting
Cranes	Electricity	Hoisting
Mechanical auger	Diesel	Boring
Trenching machine, grader, bulldozer and angle dozer, scraper	Diesel	Excavation
Pumps	Electricity, Petrol, Diesel	Surface treatment and Water for works
Compressors	Electricity, diesel, petrol	Supply compressed air

(Source: Talukhaba et al, n. d.)

2.1 Impacts of Energy Access

Energy access is a state where households enjoy unrestricted access to reliable and affordable energy supply (Karanja *et al.*, 2017). The International Energy Agency (IEA) (2011) defines Universal Energy Access as "a household having reliable and affordable access to clean cooking facilities, the first electrical connection and then an increasing level of electricity consumption overtime to reach the regional average". The World Energy Outlook (2015) described energy access in terms of a specified minimum level of electricity consumption based on the household's location (rural or urban area). The minimum level of electricity consumption for rural households is assumed to be 250 kilowatt-hours (kWh) per year and 500 kWh per year for urban households (IEA, 2015). In a report by Sustainable Energy for all's Global Tracking Framework (GTF) (2013) energy access was described by developing a multi-tier framework (MTF). Thus, energy access is the availability of adequate, reliable, clean, convenient, affordable, quality, and healthy energy.

Several studies have considered the impacts of energy access. Tarun et al. (2013) evaluated the impacts of electricity available on the performance of rural SMEs. The study highlighted the impacts as low connection cost and cheap energy, uninterrupted service, reduced manpower and labour cost, higher profit margin, provision of quality products, growth and expansion of micro-enterprises, increase in women literacy rate, and economic advancement of women. Porcaro et al. (2017) examined modern energy access and health. The study considered energy access and health implications, with energy access and reliability gaps, at two levels: electrification of health care facilities and household energy. It revealed that access to modern energy enables: the usage of most of the basic life-saving interventions thus health workers report a fewer delay in providing life-saving care; ability to refrigerate vaccines; operation of basic amenities, including lighting, ventilation, and communication systems; safe management of medical waste; availability of information and communication (ICT) services.

Barnes et al. (2014) studied the development impact of energy access. The study revealed that impacts of clean energy access on economic development are the allocation of household time (especially women) previously spent on provision of energy towards improved education, income generation, and greater specialisation of economic functions; economies of scale in more industrial type energy provision; greater flexibility in time allocation through the day and evening; enhanced productivity of business and farms; improvement in education; health-related benefits -reduced smoke exposure, clean water, and refrigeration. Muawya and Walter (2012) submitted that access to affordable and reliable energy services will promote economic development through an increase in productivity, creation of activities that generate income, improvement in the creation of employment locally, reduced household expenses on cooking, lighting, and space heating, enhanced irrigation which increases food production and access to nutrition, and access to clean water, which improves health.

Bhandari (2007) investigated the impact of household access to energy on education. The study revealed that the time spent in learning and other activities such as travel to the place of study, doing course work, and assignments are dependent on the type of energy used by a household. Guye (2017) carried out a study on the impact of electricity access on education in Kenya. The study submitted that households with access to electricity have 4.08 more years of schooling on average compared to ones that do not. In a report submitted by ACP-EU Energy Facility (2010), the positive impacts of energy access on development are increased productivity, effective delivery of health services (longer operation hours, utilisation of life support and diagnostic equipment, vaccine refrigeration), extended opening hours for adult education, increased studying hours for children, and improved access to communication technology. Olanrele et al. (2020) opined that household access to grid electricity reduces children's study hours and decreases the rate of indoor air pollution.

Trace (2016) submitted that energy access promotes economic development, reduces poverty, increases productivity, promotes effective communication and delivery of information, improves transportation system, and enhances commerce and trade, agro-processing, small-scale manufacturing, and industry. World Bank (2008) submitted that access to energy leads to improved quality of schools through the availability of electricity-dependent equipment, increasing teacher quantity and quality, and increased study time. Sovacool (2014) reported that energy access leads to improved lighting and extended studying hours, use of ICT for learning, enhanced teacher retention, improved students' performance, improved sanitation and health, gender empowerment, and community resilience. Wagner et al. (2017) studied the potential links between electrification and education. The study reported that energy access enables studying after school hours, improves productivity and efficiency of other work, powers devices or IT services that enables learning, and improves educational outcome indirectly through improving health and well-being.

3 Methodology

This paper examines the impacts of energy access in the delivery of construction projects in the Lagos metropolis. Lagos, which is located in the Southwestern part of Nigeria, is the economic hub of Nigeria. Consequently, it is the most populated and fastest developing city in the nation, resulting in the demand for more infrastructures ranging from building to civil works. The research employed a quantitative research method through a questionnaire survey. The sampling technique used for this research work was purposive sampling. The variables and constructs used in this paper were established through an extant review of existing pieces

of literature. A list of energy access impacts was adapted from the literature to formulate the research instrument.

The questionnaire was divided into two parts. The first section solicited information about each firm and its responding officer: firm's size, revenue, responding officer's designation, highest academic qualification, and years of experience; Section B sought information on the impacts of energy access on the delivery of construction activities in Lagos Metropolis. The responses of these firms in section B were obtained on five Likert scales. According to Lagos State Procurement Journal (2018), the number of companies registered with Lagos State Government (LSG) are 1929. They are grouped into classes based on the contract value they can handle. Class A is the lowest class and comprises companies that can handle contracts up to 10 million naira in value while class E is the highest with the ability to handle contracts above 1 billion naira. Others are shown in Table 2. However, the journal did not specify which of the companies are into construction. Thus, a pilot study was carried out by searching their names on google for their profile and scope of work. The result revealed that there are 62 registered construction firms in class A. 71, 294, 198, and 175 in class B, C, D, and E. However, 15% of the sampling frame was considered in determining the sample size for the study, which gave 9, 11, 44, 30, and 26 construction firms in classes A, B, C, D, and E, respectively. Thus, the total sample size was 120. The construction firms were further categorised into small, medium and large firms as follows; classes A and B were classified as small firms, firms in class C were classified as medium firms while firms in classes D and E were classified as large firms. The respondents from the construction firms were construction professionals: architects, structural, civil, mechanical, and electrical engineers, builders, and quantity surveyors. However, the internal validity of the constructs was ascertained by reviewing the questionnaire went through a peer-reviewed process and assessment by the research supervisor before it was administered. As the principal researcher, the lead author of this paper administered the questionnaire to the respondents physically.

A total of 89 construction firms responded to the survey—a response rate of 74.0%. IBM SPSS Version 23 was employed to analyse the data retrieved from the survey. The descriptive statistics employed were mean score ranking and frequency while the inferential statistics used was the Kruskal-Wallis test. The mean score ranking generated the significance index of the impacts of energy access. The result of the Kruskal-Wallis test determined the level of significance of the agreement between the respondents.

4 Findings and Discussion

The section presents the data collected, analysis carried out, and results generated as well as a discussion of findings.

4.1 Background Information on Firms and Responding Officers

Table 2 shows the general information about the firms surveyed and the responding officers. The results showed that 15 (16.8%) are small firms, 32 (36.0%) are medium firms and 42 (47.2%) are large firms. An evaluation of the academic qualification of the responding officers showed that about 39.3% have B. Sc. while only 7.9% have M.Sc. However, the highest proportion of the responding officers are engaged as engineers 38 (42.7%). This is because engineers are more predominant on site. The least represented professionals 6 (6.7%) are architects. This is because most architects are not residents on-site rather, a clerk of work represents them. It emerges that 66 responding officers (65.2%) have been active participants

in the construction industry for less than 10 years while only 23 (25.9%) have been involved in construction activities for 10 years and above.

Table 2. Background Information on Firms and Responding Officers

	Frequency (f)	Valid Percent	Cumulative Percent
Size of the Firm			
Small	15	16.8	16.8
Medium	32	36.0	52.8
Large	42	47.2	100.0
Highest Academic Qualification of the Respondents			
OND	13	14.6	14.6
HND/PGD	34	38.2	52.8
B. Sc.	35	39.3	92.1
M. Sc.	7	7.9	100.0
Professional Designation of the Respondents			
Architect	6	6.7	6.7
Quantity Surveyor	25	28.1	34.8
Builder	20	22.5	57.3
Engineer	38	42.7	100.0
Years of Experience of the Respondents			
0 - 5	31	34.8	34.8
6 - 10	35	39.3	74.1
11 - 15	15	16.9	91.0
16 - 20	3	3.4	94.4
Above 20	5	5.6	100.0
Mean = 7.88			

4.2 Impacts of Energy Access on the Delivery of Construction Projects.

The result presented in Table 3 shows the impacts of energy access on construction project delivery. For small firms, improved economy (MS= 4.50) ranked first as the most significant impact of energy access on construction project delivery. Efficacy in project delivery (MS= 4.43) ranked second. Increased employment (MS= 4.33) ranked third. Improved effectiveness of project delivery (MS= 4.29), fast-tracked delivery of construction projects (MS= 4.29), and increased productivity (MS= 4.29) ranked fourth. The least significant impact was enterprise creation (MS= 3.50). The most significant impact of energy access by medium firms was the fast-tracked delivery of construction projects (MS= 4.78). Closely followed by increased productivity (MS= 4.72). The least significant impact of energy access was increased employment (MS= 4.09). For large firms, the most significant impact was improved economy (MS= 4.50). Closely followed by increased productivity (MS= 4.41). Finally, the least significant impact of energy access was saves cost overtime (MS= 3.85). The overall evaluation of the general view of the respondents on energy access impact on construction project delivery revealed that all the effects identified had a mean score greater than 3.00 which is the midpoint in a 5-point scale. This implies that all the identified variables were impacts of energy access.

Increased productivity (MS= 4.53) ranked first as the most significant impact of energy access on construction project delivery. Fast-tracked construction project delivery (MS= 4.50) ranked second. Improved economy (MS= 4.46), improved effectiveness of project delivery (MS= 4.36), reduced stress of manual labour (MS= 4.30) ranked third, fourth and fifth respectively. The least ranked impact was improved lighting conditions (MS= 4.05). This result conforms with the previous research findings that identified the highlighted benefits as significant

impacts of energy access (ACP-EU Energy Facility, 2010; Barnes, 2014; Muawya & Walter, 2012; Tarun et al., 2013; Trace, 2016; Wagner et al., 2017).

Table 3: Impacts of Energy Access on Construction Project Delivery Based on Size of Firm

S/N		Size of firm								Kruskal Wallis Sig.
		Overall		Small		Medium		Large		
		Mean	Rk	Mean	Rk	Mean	Rk	Mean	Rk	
1	Increased productivity	4.53	1	4.29	4	4.72	2	4.41	2	.209
2	Fast-tracked construction project delivery	4.50	2	4.29	4	4.78	1	4.32	3	.028
3	Improved economy	4.46	3	4.50	1	4.41	5	4.50	1	.869
4	Improved effectiveness of project delivery	4.36	4	4.29	4	4.48	3	4.28	4	.773
5	Reduced stress of manual labour	4.30	5	4.14	7	4.44	4	4.22	5	.545
6	Use of communication technologies	4.24	6	4.00	9	4.38	6	4.18	7	.909
7	Triggers efficacy in project delivery	4.20	7	4.43	2	4.38	6	4.02	9	.514
8	Increased employment	4.18	8	4.33	3	4.09	11	4.22	5	.859
9	Enterprise creation	4.08	9	3.50	11	4.13	10	4.13	8	.372
10	Saves cost overtime	4.07	10	4.14	7	4.34	8	3.85	11	.200
11	Improved lighting conditions	4.05	11	3.71	10	4.19	9	4.00	10	.694

The findings of the present study agree with ACP-EU Energy Facility (2010). The study highlighted the positive impacts of energy access on development as increased productivity, effective delivery of health services (longer operation hours, utilisation of life support and diagnostic equipment, vaccine refrigeration), extended opening hours for adult education, increased studying hours for children, and improved access to communication technology. Furthermore, the findings of this study agree with Barnes (2014) who submitted that impacts of higher-quality energy and better use of existing fuels on economic development are the relocation of household time (especially women) away from energy provision and towards improved education, income generation, and greater specialisation of economic functions; economies of scale in more industrial type energy provision; greater flexibility in time allocation through the day and evening; enhanced productivity of business and farms; improvement in education; health-related benefits -reduced smoke exposure, clean water, and refrigeration.

This study also agrees with Muawya & Walter (2012) who submitted that access to affordable and reliable energy services will facilitate economic development through increased productivity, income-generating and livelihood activities from extended lighting, improved local employment creation, reduction in household income spent on cooking, lighting, and space heating, enhances irrigation which increases food production and access to nutrition, and access to clean water which improves health. The findings are in agreement with Tarun et al. (2013). The study highlighted the impacts as low connection cost and cheap energy, uninterrupted service, reduced manpower and labour cost, higher profit margin, provision of quality products, growth and expansion of micro-enterprises, increase in women literacy rate, and economic advancement of women.

Further analysis was carried out to test the level agreement of respondents on the impacts of energy access on construction projects using the Kruskal Wallis test. The result shown in Table 4 indicated that eleven of the twelve identified impacts had a significance value greater than 0.05. This implies that there is no difference in the perception of the respondents on these

impacts. However, one of the impacts had a significance value less than 0.05: makes construction project delivery faster (sig= 0.028). This implies that there is a difference in the perception of respondents on this impact based on their size of the firm.

5 Conclusion and Recommendations

This paper examined the impacts of energy access on the delivery of construction projects. The study established that the most significant impact of energy access on the delivery of construction projects in Nigeria is increased productivity. Others are fast-tracked construction project delivery, improved economy, improved effectiveness of project delivery, reduced stress of manual labour. The study concluded that energy access will enhance the delivery of construction projects through improved productivity and project effectiveness. Therefore, the study recommends that the Nigerian government should enhance the generation and access to clean energy for construction activities so that the dividends of energy access can be made available to all, through improved productivity which in turns increases employment opportunities as it has been established that the construction industry is one of the largest employer of labour in the country. It is also noteworthy that the construction industry improves the economy of a nation. Thus, the Nigerian government will facilitate more construction activities by formulating policies that aid efficient generation and access to clean energy.

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