Exploring the perception of Nigerians towards nuclear power generation

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To decarbonize the Nigerian power sector and ensure a reliable electricity supply, nuclear power will play a key role. However, public acceptance must be considered for the successful introduction of nuclear power. This study examines the perceptions of Nigerians towards nuclear power generation and its opportunity as a viable source of power in Nigeria. The study adopts a quantitative method through surveys, using simple random sampling by administering questionnaires of structured close-ended questions to 10,001 respondents via social networking services and hand-delivered questionnaires. However, the response rate was only 71%. The data were analyzed using Pearson's Product Moment Correlation to measure the relationship between the various perceptions of nuclear power as a viable solution to the electricity problems in Nigeria using the statistical analysis software, Statistical Product and Service Solutions Statistics (IBM SPSS). The Cronbach's alpha value of 0.821 of the items (questions) illustrates the acceptable internal consistency of the study and shows that it has reliability and validity on a five-point Likert scale. The study shows that over 56% of the respondents support the use of nuclear power generation as a viable option for electricity supply in Nigeria. Furthermore, it is recommended as a boost to the Nigerian economy, safety, security, and environmental sustainability, therefore, indicating positive perceptions towards building a nuclear power plant in Nigeria.

Keywords: electricity, public perception, nuclear power, energy policy, Nigeria

Introduction

Modern energy access has been identified as the 'gum' that binds economic development, human wellbeing, and environmental sustainability (IEA 2017). However, today, about 80% of the world's primary energy supply is from fossil fuels (IEA 2019). The combustion of fossil fuels for different economic activities contributes to climate change (IPCC 2014). In terms of vulnerability to climate change, developing countries like Nigeria have been identified to be at higher risks (TERI 2015) than developed countries. Nigeria remains the most populous country in Africa (201 million persons as of 2019), and has the largest economy in the continent (Dioha 2020). In terms of access to modern energy, around 39% of the population does not have access to electricity (IEA 2017).

Owing to the projected population growth and the yearning for economic development, the energy demand of Nigeria is expected to increase in the future. Given the fact that Nigeria's commercial energy supply is dominated by fossil fuels, it is expected that future energy demand will lead to increased use of finite fossil fuels which contributes to climate change (Dioha, Emodi, and Dioha 2019; Nnaji et al. 2019). The global goal is to mitigate greenhouse gas (GHG) emissions and to provide sustainable energy for all. This will require significant investments in new energy infrastructures. Consequently, providing modern energy for all at an affordable price without impeding environmental sustainability remains a trilemma for Nigerian decision-makers. The country has made efforts over the years to improve renewable power deployment in the country, but amidst this, the growth of renewables is still slow in the country (Gungah, Emodi, and Dioha 2019), and the cost of generating electricity from renewables in the country is still relatively high compared to the conventional technologies (natural gas) (Roche, Ude, and Donald-Ofoegbu 2017). Beyond cost, renewables are also plagued with the problem of variability in supplies and this creates a challenge for moving towards a 100% renewable energy system in the future (Tambari, Dioha, and Failler 2020).

To address the issues of modern energy access, climate change, affordability of energy, as well as the variability of renewables, nuclear power will play a key role (OECD 2010). Presently, nuclear power is not part of the Nigerian energy mix (Ley, Gaines, and Ghatikar 2015). However, the Nigerian National Energy Masterplan seeks to promote and develop 1 GW of nuclear power by 2025. Whether this target will be achieved or not is beyond the scope of this paper. Despite the potential of nuclear power to address many of the current challenges of the energy system, it remains a controversial technology with respect to public acceptance. Amongst other limiting factors, successful deployment of nuclear power in Nigeria will depend on the perception or acceptance of the technology by the Nigerian public, and this is strongly tied to the potential benefits and risks involved while introducing the technology (Oludare et al. 2014). This study therefore seeks to understand the perception of Nigerians towards nuclear power deployment in the country.

The remainder of this study is structured thus: The next section presents the literature review – capturing the evolution of the literature in this domain and an overview of the current situation of nuclear power development in Nigeria. This is followed by a section that describes the methodology employed in the study. In the penultimate section we present the results of the study with the associated discussion, while in the final section we conclude the study with some recommendations.

Literature review

The literature and its evolution

Government and stakeholders need public acceptance of nuclear power technology; as a consensus is a pre-condition to drive government actions on nuclear power especially in a democratic country like Nigeria (Wüstenhagen, Wolsink, and Bürer 2007). As per the International Atomic Energy Agency (IAEA) 19 nuclear infrastructure issues, stakeholders involvement is a pre-requisite for a successful nuclear power programme (IAEA 2015). Government programmes for nuclear power development are promoted by stakeholders support, which is in turn, facilitated by effective stakeholders' involvement such as the general public (IAEA 2015). Therefore, governments considering to adopt nuclear power in their energy systems need to assess the public perception/acceptance of the technology, because better acceptance of the technology will ensure stable operation as well as adequate handling of nuclear wastes generated from nuclear reactors (Roh 2017). In this context, the need for Nigeria to assess its citizens' perceptions if it plans to deploy nuclear power in its energy system becomes clear.

In the open literature, several studies have investigated the public perception/acceptance of nuclear power. Some of these showed that public acceptance of nuclear energy can be affected by risk perception variables, rationality, policy executor, knowledge of nuclear technology, emotion, trust, and economic benefits (Mberia 2017; Roh 2017). In Song and Kim (2013), the effects of trust, stigma, and optimistic bias in the public perception of the risk of nuclear power plants was examined. Their findings showed that stigma has a significant negative effect whereas optimistic bias has no significant effect on the trust of the general public about nuclear power plants. The relationship between public perception and acceptance of nuclear power has also been recognized by several research studies. In Frantál and Malý (2017), a regression model was used to investigate the factors that affect local community support for the rebuilding of an existing nuclear power plant in the Czech Republic. Negative attitudes to the growth of renewable energy and the perception that nuclear energy is clean energy that can mitigate climate change are the strongest predictors of their support. The perception indicates the environmental challenges such as air pollution and soil damage (Van der Pligt, Eiser, and Spears 1986) which are associated with nuclear power generation are critical risk factors.

Similarly, in Misnon et al. (2017), a survey was conducted to investigate public perception and acceptance of nuclear power in Malaysia. Their findings showed that because Malaysians enjoy a relatively stable power supply, energy-related issues are not a primary concern to the Malaysian public. However, a vast majority of them see nuclear energy and other forms of renewable energy as a source of guaranteed energy supply in the future. In Choi, Kim, and Lee (2000), the authors proposed a perception model that can be used to investigate the perceived risk and benefit of nuclear power. Furthermore, in Takebayashi et al. (2017), an assessment of the risk perception or anxiety of nuclear radiation after the 2011 Fukushima nuclear power accident was carried out among the residents of Fukushima. The results of the survey showed a decrease in radiation-related anxiety among Fukushima residents from 2012 to 2015. In a related study (Kristiansen, Bonfadelli, and Kovic 2018), the risk perception of nuclear energy after the Fukushima was conducted in Switzerland from 2012 to 2014. The objective of the study was to determine how the perception of nuclear energy had changed and which factors had influenced public perception since the accident. The findings of the survey showed that the perception of the public became slightly positive with the passage of time.

The significance of policy executors in the public perception of nuclear power cannot be overemphasized. For example, in South Korea, a major socio-political controversy around energy transition has begun since President Moon Jae-in came into office in 2017. In Chung and Kim (2018), the public perception on the nexus between nuclear power, climate change, and party preference was conducted in Korea. The study showed that Korean energy policy can only be deliberated through a democratic process. This is because most Koreans perceive nuclear energy as strictly a political issue rather than a scientific or economic matter. However, the insights gathered from the study in Valentine and Sovacool (2019) on the establishment of the nuclear power programme in Japan showed that a framework can be developed to alter the public perception through a change management theory.

Once more, Kim (2018) showed that public risk perception can be affected by opposing government policy. In Seoul for instance, findings showed that the risk perception of nuclear power increased because of the government policy to phase-out nuclear power. Whereas, in 2009 the growth in anxieties about climate change and the government policy of 'low carbon green growth' which are nuclear-friendly increased the perception of the benefits of nuclear energy. Drawing from the insights gleaned from Asia and Europe, related surveys have also been performed in the African continent to determine the perception of the public on nuclear power energy. In Mberia (2017), a survey was performed to understand the perception of the Kenyan public towards nuclear electricity generation. Data collected from 96 respondents who are randomly selected from a target population were used for this study. The results showed that 70.83% of the respondents support the addition of nuclear power in the energy mix of Kenya, whereas, only 29.17% opposed it.

However, in Nigeria, studies that have investigated what the Nigerian public sentiment is on nuclear power as an alternative energy source are limited. In Sambo and Abuh Rafiu (2019), a survey was conducted to study the perception of Nigerians on nuclear energy. Here, we complement this earlier study by surveying a larger sample size on their perception toward the deployment of nuclear power generation in Nigeria through electronically administered questionnaires. In our survey, we collected big data from three social networking services (SNSs), i.e. Facebook, WhatsApp, and LinkedIn. We also distributed physical questionnaires for people without access to internet facilities. Our datasets are analyzed using various statistical parameters. With respect to contribution to the existing literature, this paper introduces one of the earliest studies on this topic for Nigeria. The paper, in a useful manner, seeks to improve the evidence-based assessment needed to inform policies regarding the introduction of nuclear power into the Nigerian energy system. Beyond Nigeria, the findings of the study will be essential for many countries considering the deployment of nuclear power generation, especially those who share similar national circumstances with Nigeria.

Overview of nuclear energy in Nigeria

Undoubtedly, in Nigeria, there have been numerous efforts to explore the possibility of nuclear energy, starting with the enactment of the Nigeria Atomic Energy Commission (NAEC) Act in 1976. The Federal Government of Nigeria (FGN), in 1978 established the first two university-based research and training centres: Centre for Energy Research and Development (CERD) at the Obafemi Awolowo University, then University of Ife, Ile-Ife, and the Centre for Energy Research and Training (CERT) at the Ahmadu Bello University, Zaria. Despite the enactment of the NAEC Act, the NAEC was only fully activated and became fully operational in July 2006. With respect to the regulation of nuclear activities in Nigeria, the Nigerian Nuclear Regulatory Authority (NNRA) was created by Act 19 of 1995 and mandated to regulate all nuclear activities in the country, including the enforcement of all nuclear laws and regulations. However, NNRA was only activated and became operational in May 2001. Since 2006, the capacity building and infrastructure development components of the national nuclear programme have been expanded with the addition of four nuclear research centres, bringing the number of nuclear research-based centres under the aegis of the NAEC to seven, namely:

- Centre for Energy Research and Training (CERT), Ahmadu Bello University, Zaria, Kaduna State;
- Centre for Energy Research and Development (CERD), Obafemi Awolowo University, Ile-Ife, Osun State;
- Nuclear Technology Centre (NTC), Sheda Science and Technology Complex, Abuja, FCT;
- Centre for Nuclear Energy Studies (CNES), University of Port-Harcourt, Port-Harcourt;
- Centre for Nuclear Energy Research and Training (CNERT), University of Maiduguri, Maiduguri;
- Centre for Nuclear Energy Studies and Training (CNEST), Federal University of Technology, Owerri;
- FGN-IAEA Marine Contamination Coastal Field Monitoring Station (MCCFMS), Koluama.

However, it is worth stating that the FGN-IAEA Marine Contamination Coastal Field Monitoring Station (MCCFMS), Koluama is simply a monitoring station (no research activities occur there). NAEC is partnering with these institutions to develop and implement education and training curricula for the building of professionals in nuclear science and engineering, technologists and technicians, and craftsmen. This has necessitated the creation of new programmes where they do not exist and modifications of existing programmes to meet its needs. In the past 10 years, NAEC has increased efforts towards commissioning its first nuclear power plant. A roadmap developed by the Commission calls for 1000 MW of nuclear power by 2027 and 4000 MW by 2037. Thus, Nigeria has made a policy decision to pursue nuclear power and is currently undertaking the necessary preparatory work to invite the first bid for construction. Despite the progress made by the NAEC which includes the ratification of international treaties, the development of robust regulatory architecture, and the signing of bilateral technical cooperation agreements, there are still significant challenges ahead. These include an underdeveloped electricity grid, poor electricity market, lack of technical capacity, funding challenges, public acceptance, etc. All these make the proposed NAEC timelines shaky and with the present financial and political climate, it is unlikely that Nigeria will begin construction of a nuclear power plant before 2023.

With respect to exploration activities, uranium mining was initiated by the defunct Nigeria Uranium Mining Co. Ltd. (NUMCO) which was established through Nigeria-France collaboration. Ever since then, uranium has since been discovered in seven states of the country: Cross River, Adamawa, Taraba, Plateau, Bauchi, Kogi, and Kano states. At the end of the various exploration campaigns in 2001, the uranium reserve was estimated at 200 t U. The grade ranges from 0.63% to 0–9% at a vertical depth between 130–200 m (Karniliyus and Egieya 2014). Within the period of initial uranium exploration, initial project feasibility and NPP siting activities were carried out. Implementation of project elements in the areas of human resources development (HRD), uranium exploration, and nuclear power plant (NPP) siting, were done in collaboration with Bureau de Recherches géologiques et minières (BRGM), a Swiss-based engineering consultant (Motor Columbus), and other foreign technical partners (Karniliyus and Egieya 2014). At that time, the nuclear power development process was hampered because the programme execution did not follow any clearly defined roadmap. Hence implementation of various aspects of the development of the national nuclear power programme by the various government agencies was not properly coordinated. With the activation of NAEC, an announcement was made in 2010 for the assessment of four sites as potential locations of the proposed nuclear power plant. The sites were carefully chosen to cover different regions of the country. They include Itu in Akwa- Ibom state for the South-South region, Geregu in Kogi state for the North-Central zone region, Agbaje in Ondo state for the South-West region, and Lau in Taraba state for the North-East region. After further site evaluation and impact assessment in 2015, by a specialized team at NAEC, Geregu and Itu were confirmed as the preferred locations. In 2017, Nigeria and Russia signed agreements on the construction and operation of a nuclear power plant and a nuclear research centre, including a multi-purpose research reactor.

Methods

As a quantitative survey, primary data were gathered using structured closed-ended questions. This method was adopted to cover practical representatives and generate a large sample size within a short period. Each question was derived from scaled responses (i.e. a five-point Likert scale) for validity allowing the respondents to express their strength in opinions on the directions of the questions asked. The questionnaire design, following the conceptual framework of the study (See Appendix A), covered two sections;

Section 1: Questions on familiarity and a general understanding of electricity supply and nuclear power generation, and
Section 2: Questions on perceptions towards nuclear power generation and factors associated with nuclear energy.

Determination of sample size

Many methods may be used in the determination of a credible sample size that provides an accurate representation of the characteristics of the population. These methods as seen in Singh and Masuku (2014) include:

1. Using a census for small populations.
2. Imitating a sample size of similar studies.
3. Applying formulae to calculate a sample size.
4. Using published tables.
5. Use computer software e.g., EPI – info series.

However, for this study, since our population was large, the use of a census was eliminated due to the huge cost implication. On the other hand, imitating a sample size of similar studies may be misleading and prone to errors due to the peculiar nature of each study. Finally, the computer software was eliminated due to accessbilty issues. This left us with either used published tables or applying formulae. Hence, as a matter of choice, the well-known Yamane formulae (Yamane 1967) was used in the determination of the sample size. This is an ideal method when the only thing you know about the underlying population being sampled from is its size. The Yamane sample size states that:

$$n = \frac{N}{(1 + Ne^2)} \tag{1}$$

where

n = sample size
N = population size
e is the acceptable sampling error which is determined from the confidence level of the study.

That is, if we want to be 98% sure about the results of our study then $e = 0.02$.

Since the projected population of Nigeria is about 200,000,000 according to data received from the Nigeria Bureau of Statistics, at 2% margin of error, the sample size would be:

$$n = \frac{N}{(1 + Ne^2)}$$

$$n = \frac{200000000}{[1 + (200000000 \times 0.02^2)]}$$

$$n = \frac{200000000}{80001}$$

$$n = 2\,499.968$$

Hence, the calculated sample size equals 2500 (to the nearest hundred).

The study was conducted through random sampling and the actual sample size was targeted as 10,000 respondents (4 times the calculated sample size). The survey was done using physical questionnaires and internet (ethnographic) observation to collect data (Saunders, Lewis, and Thornhill 2016). However, due to internet challenges in the country, some of the respondents did not fully complete the online survey, prompting the authors to clear the incomplete responses from the data. In adddition, not all the questionnaires were returned, giving a combined total response rate of 71%.

The study targeted respondents aged 18 years and above, from different cities in Nigeria and different areas of specialization.

The hypotheses for the study that are tested to assess the strength of the relationship between the variables (Saunders, Lewis, and Thornhill 2016) are:

Null hypothesis, H_0: There is no statistically significant relationship between the variables
Alternate hypothesis, H_1: There is a statistically significant relationship between the variables.

The variables for the study to test the hypothesis:

- N1 – Electricity supply as a serious problem
- N2 – Nuclear power generation as a viable option
- N3 – Knowledge of climate change and its causes
- N4 – Mitigate climate change
- N5 – Radioactive waste disposal as a barrier
- N6 – Political unrest and increased insurgency
- N7 – Adequacy of skills to respond to accident
- N8 – Inadequate maintenance skills
- N9 – Environmental challenges
- N10 – Infrastructural challenges
- N11 – Negative media
- N12 – Past nuclear accidents
- N13 – Distrust among political elites and masses
- N14 – Finance
- N15 – Create additional employment opportunities
- N16 – Support as an alternative solution for electricity supply
- N17 – Location of nuclear power generation plant

For the dependent variable, N, nuclear power generation, hypotheses are:

- $N2H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and electricity supply as a serious problem
- $N2H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and electricity supply as a serious problem
- $N3H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and knowledge of climate change and its causes
- $N3H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation knowledge of climate change and its causes
- $N4H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and mitigate climate change
- $N4H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation mitigate climate change
- $N5H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and radioactive waste disposal as a barrier
- $N5H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation Radioactive waste disposal as a barrier
- $N6H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and political unrest and increased insurgency
- $N6H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and political unrest and increased insurgency
- $N7H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and adequacy of skills to respond to accident
- $N7H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and adequacy of skills to respond to accident
- $N8H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and inadequate maintenance skills
- $N8H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and inadequate maintenance skills
- $N9H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and environmental challenges
- $N9H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and environmental challenges
- $N10H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and infrastructural challenges
- $N10H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and infrastructural challenges
- $N11H_0$: Null hypothesis – There is no statistically significant relationship between Negative Media and Past nuclear accidents
- $N11H_1$: Alternate hypothesis – There is a statistically significant relationship between Negative Media and Past nuclear accidents
- $N12H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and past nuclear accidents
- $N12H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and past nuclear accidents
- $N13H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and distrust among political elites and masses
- $N13H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and distrust among political elites and masses
- $N14H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and finance
- $N14H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and finance
- $N15H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and create additional employment opportunities
- $N15H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and create additional employment opportunities
- $N16H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and support as an alternative solution for electricity supply
- $N16H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and support as an alternative solution for electricity supply
- $N17H_0$: Null hypothesis – There is no statistically significant relationship between nuclear power generation and the location of nuclear power generation plant
- $N17H_1$: Alternate hypothesis – There is a statistically significant relationship between nuclear power generation and the location of nuclear power generation plant

The questionnaires were administered to 10,001, but only 7102 respondents fully completed the questionnaires and were considered valid and used for further analysis. The measure of the internal consistency of the responses was conducted for reliability using the Cronbach's alpha test extensively for the selected items (questions), (Cronbach 1951; Hair et al. 2006). The results show a Cronbach's alpha coefficient of 0.821, which is above the minimum 0.70 and very acceptable as argued by Gliem and Gliem (2003) and Tavakol and Dennick (2011). This indicates there is an internal consistency in the question construct based on the five-point Likert scale of the responses.

The data collected were analyzed using the statistical tool SPSS for the quantitative data. Correlation analysis, Pearson's Product Moment Correlation Coefficient (PMCC) is used to describe or assess the strength (magnitude) and direction of the linear relationship between two numerical variables (Saunders, Lewis, and Thornhill 2016). Correlation coefficient (represented by Rho, r)

ranges from −1 to 1, from a negative correlation to a positive correlation (Cohen 1992; Sullivan and Feinn 2012). Pearson's Correlation Coefficient is defined in Equation 2 (Ahlgren, Jarneving, and Rousseau 2003);

$$r = \frac{\sum (X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum (X - \bar{X})^2 \sum (Y - \bar{Y})^2}} \quad (2)$$

In Equation 2, X denotes the variables (explanatory/independent variable; N1, N3, N4, N5, N6, N7, N8, N9, N10, N12, N13, N14, N15, N16, N17). On the other hand, Y denotes the variables (dependent variables; N2 – nuclear power generation and N11 – Negative media). The correlation analysis done for this study is (N2 as dependent variable vs N1, N3, N4, N5, N6, N7, N8, N9, N10, N12, N13, N14, N15, N16, N17), and N11 as a dependent variable (for N11 vs N12) to measure the perception of the respondents towards nuclear energy generation. Furthermore, $\bar{X}$ represents the mean of X variables while $\bar{Y}$ represents the mean of Y variables.

A correlation of 0 indicates no relationship between the variables, a correlation of −1 indicates a perfect negative correlation and a correlation of 1 indicates a perfect positive correlation (Pallant 2013; Saunders, Lewis, and Thornhill 2016). The quantitative data consist of 17 variables which are measured to assess the strength (magnitude) of the relationship. The probability, p of the confidence level (significance) is less than 0.05; therefore, a p-value of less than 0.05 has a statistically significant relationship, while a p-value greater than 0.05 has no statistically significant relationship (Saunders, Lewis, and Thornhill 2016). Table 1 illustrates the range of the correlation coefficients.

Table 1: Correlation coefficient values.

Correlation Coefficient	Value
Strong negative	$r = -0.50$ to -1
Moderate negative	$r = -0.30$ to -0.49
Weak negative	$r = -0.10$ to -0.29
None	$r = -0.09$–0.09
Weak positive	$r = 0.10$–0.29
Moderate positive	$r = 0.30$–0.49
Strong positive	$r = 0.50$–1

Source: Cohen (1992); Saunders, Lewis, and Thornhill (2016)

Results and discussion

In this section, we present the numerical results and analysis of the survey data distinctly for each of the test variables. From the results, Table 2 shows the demographics of the respondents during the study. We analyzed the survey results in terms of the percentage of agreement and degree of correlation. In Table 3, we present the results of the respondents' answers which is then followed by an analysis of the results for each variable (N1–N17).

Table 2: Demographics of the respondents.

Demographics	Description	%
Age	18 years–30 years	35
	31 years–50 years	45
	51 years and above	20
Location	Urban	60
	Rural	40

N1 – Electricity supply as a serious problem

On the electricity supply as a problem, observations in Table 3 shows that the majority (85.08%) of the respondents strongly agreed that the electricity supply is a problem in Nigeria, 8.74% agreed, 0.82% were undecided, 0.62% disagreed and 4.74% strongly disagreed. These results show that the respondents are familiar with the power supply status in Nigeria and gave a consistent record of the situation. There is much literature on solutions to the Nigerian electricity problem, yet, it remains to be seen how many of these solutions will be implemented.

N2 – Nuclear power generation as a viable option

The respondents strongly agreed (20.54%) that nuclear power generation is a viable option for the power supply in Nigeria. Of the respondents, 35.91% agreed, while some were undecided (21.67%) about nuclear power generation as a viable option; further, 12.39% disagreed and 9.49% strongly disagreed with it as a viable option as observed from the responses in Table 3. The correlation analysis results show there is a statistically significant but weak positive relationship between electricity as a problem and nuclear power generation as a viable option ($r = .109$, $p = .001$). The alternate hypothesis, H_1 which shows there is a statistically significant relationship between electricity as a problem and nuclear power generation as a viable option is accepted. This result supports nuclear power generation as an alternative source of energy for electricity supply. However, the continuous electricity supply issues experienced in Nigeria have highlighted the need for a stable and reliable electricity supply across the country. These results are consistent with those of Akyüz (2017), Nkosi and Dikgang (2018) and Wang and Kim (2018) who posit that the advantages of nuclear power generation such as cheap electricity and a reliable energy source led the drive for the public to support the use of nuclear power generation as an alternative source of energy.

N3 – Knowledge of climate change and its causes

The respondents from the result observations strongly agreed to (35%) having knowledge of climate change and its causes, 53% agreed, some of the respondents were undecided (10%), 1% disagreed, and 1% strongly disagreed as illustrated in Table 3. The results show that there is a statistically significant but weak positive relationship between electricity as a problem and knowledge of climate change and its causes ($r = .180$, $p = .000$). Considering earlier pieces of literature, this finding does not agree with that of Park (2019), Kovacs, Eng, and Gordelier (2010) and Misnon et al. (2017) who posited that the public's knowledge of climate change is uncertain. It thus can be seen that information transmission and knowledge can be considered a fundamental element to the public in understanding the factors of climate change and the use of specialized technologies for electricity supply.

Table 3: Respondents' responses.

Variable	Strongly agree (%)	Agree (%)	Undecided (%)	Disagree (%)	Strongly disagree (%)
N1	85.08	8.74	0.82	0.62	4.74
N2	20.54	35.91	21.67	12.39	9.49
N3	34.97	53.30	9.74	0.73	1.26
N4	13.37	33.78	28.50	16.17	8.19
N5	28.91	34.45	22.13	10.23	4.28
N6	30.94	35.10	12.81	15.00	6.15
N7	32.81	33.44	12.37	15.62	5.77
N8	46.35	39.25	3.25	7.10	3.76
N9	19.75	34.59	13.48	26.23	5.96
N10	27.48	38.14	8.25	19.96	6.17
N11	17.28	39.06	13.72	24.50	5.45
N12	18.20	42.78	14.85	19.87	4.29
N13	28.39	47.91	6.99	13.47	3.24
N14	27.11	39.21	11.26	11.57	10.84
N15	41.42	30.86	8.05	9.94	9.73
N16	44.67	30.33	6.49	10.56	7.95
N17	25.73	28.83	17.60	12.81	15.63

N4 – Mitigate climate change

It is observed that the respondents strongly agreed that (13.37%) nuclear power generation can mitigate climate change. 33.78% agreed some of the respondents were undecided (28.5%), 16.17% disagreed and 8.19% strongly disagreed as shown in Table 3. The correlation analysis shows there is a statistically significant but moderate positive relationship between nuclear power generation as a viable option and mitigation of climate change effects ($r = .365$, $p = .000$). The implication of this is that Nigerians are very much concerned about the adverse impacts of climate change and thus, believe that nuclear power will likely help to mitigate GHG emissions in the country. This result is in line with the findings of Devine-Wright (2008) who suggested that environmental concerns, especially those relating to climate change are one of the key factors driving nuclear power generation.

N5 – Radioactive waste disposal as a barrier

Observations from the results show radioactive waste disposal as a barrier to selecting nuclear power generation as a viable option for the power supply in Nigeria. Of the respondents, 28.91% strongly agreed, 34.45% agreed, 22.13% were undecided, 10.23% disagreed and 4.28% strongly disagreed with this as a viable option shown in Table 3. Table 3 shows the correlation analysis results; there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and radioactive waste disposal ($r = -.101$, $p = .002$). Therefore, the nuclear power plant needs to be located in a remote area in Nigeria to curb risks and hazards from radioactive wastes that are harmful to the people or the environment. To buttress the viability of a nuclear plant, the disposal of radioactive waste is perceived as one of the essential factors in using nuclear power generation for electricity supply. This implies that the technologies to be used in disposing of the radioactive waste need formal supervision from relevant authorities to protect the interest of the public. Furthermore, policies to guide the disposal of radioactive waste should be introduced to contain any misappropriation and inconsistent methods of the process to avoid catastrophic risk (Kovacs, Eng, and Gordelier 2010; Park 2019; Pidgeon and Demski 2012).

N6 – Political unrest and increased insurgency

For political unrest and continuous insurgency, observations show the possible effects of a barrier to building a nuclear power generation plant as a viable option for the power supply in Nigeria. Of the repondents, 30.94% strongly agreed, 35.10% agreed, 12.81% were undecided, 15% disagreed and 6.15% strongly disagreed as shown in Table 3. The correlation analysis shows there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and political/increased insurgency ($r = -.201$, $p = .000$) as shown in Table 3. Therefore, attacks and violence can be barriers to building the power generation plant due to damage to and destruction of facilities. The concern even assumes greater significance as Nigeria has experienced severe insurgency attacks, especially from Boko Haram over the last decade, which has heightened the fear of establishing nuclear power plants in the country.

N7 – Adequacy of skills to respond to accident

Observations from the results emphasize that 32.81% of the respondents strongly agreed that there is the adequacy of skills to respond to an accident if it occurs in the nuclear power generation plant, 33.44% agreed, 12.37% were undecided, 15.62% disagreed and 5.77% strongly disagreed. The correlation analysis results show that there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and adequacy of skills to respond to an accident at the plant ($r = -.206$, $p = .000$). Given that Nigeria has been experiencing different forms of disasters recently, this suggests that the government can also use its current response team to address accident response in nuclear power generation.

N8 – Inadequate maintenance skills

The result observations indicate a high percentage (46.35%) of the respondents suggested there is a lack of maintenance skills of nuclear power generation facilities which may lead to deterioration of the power generation plant and its outputs, 39.25% agreed, 3.55% of the respondents were undecided, 7.10% disagreed and 3.76% strongly disagreed. Table 3 shows the correlation analysis results indicating there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and inadequate maintenance skills ($r = -.123$, $p = .000$). The result is not surprising as Nigeria has a history of poor maintenance culture and this can also be seen in the state of the power sector today, which parades old and inefficient gas power plants (Dioha 2020).

N9 – Environmental challenges

The results indicate that 19.75% of the respondents suggested nuclear power generation may lead to environmental challenges and cause adverse effects on the environment, while 34.59% agreed, 13.48% of the respondents were undecided, 26.23% disagreed and 5.96% strongly disagreed as observed in Table 3. The correlation analysis results illustrate there is a statistically significant but weak negative relationship between nuclear power generation and environmental challenges ($r = -.237$, $p = .000$). From the results, nuclear power generation is considered not friendly to the environment. To expatiate the situation, the adverse effects of nuclear power generation on the environment have numerous challenges, such as soil damage to farming, air pollution, habitation of humans, and building destruction (Van der Pligt, Eiser, and Spears 1986). These effects can be considered factors that are not sustainable and cause harm to human lives and the environment, like the case of Chernobyl, Ukraine in 1986, where the environment was lost due to nuclear disaster from nuclear power generation. Environmental protection has been the ultimate goal of sustainable growth and, as such, adhering to approaches that value the protection of the environment are front runners of any project (Kovacs, Eng, and Gordelier 2010; Misnon et al. 2017; Park 2019).

N10 – Infrastructural challenges

Observations from the results emphasize a high percentage (38.14%) of the respondents suggested infrastructural challenges may be a barrier to building of a nuclear power generation plant, 27.48% agreed, 8.25% of the respondents were undecided, 19.96% disagreed, and 6.17% strongly disagreed illustrated in Table 3. The correlation analysis results indicate that there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and infrastructural challenges ($r = -.181$, $p = .000$).

N11 – Negative media

The observation of the results postulates that the media play a significant role in transmitting information based on past nuclear accidents. Of the respondents, 17.28% strongly agreed, 39.06% agreed, 13.72% were undecided, 24.50% disagreed and 5.45% strongly disagreed (Table 3). The correlation analysis results show that there is a statistically significant but moderate positive relationship between negative media and past nuclear accidents ($r = .384$, $p = .000$). From the above, it can be deduced that the media play a role in propagating public opinions on the use of nuclear power generation as a viable option for electricity supply. The media highlight information that can either have positive or negative effects (Park 2019), thus, permutating the decision-making mechanism of the public's opinions on nuclear power generation and its technologies.

N12 – Past nuclear accidents

The results observed indicate a percentage (18.20%) of the respondents suggested past nuclear accidents can be a barrier to building a nuclear power generation plant, 42.78% agreed, 14.85% of the respondents were undecided, 19.87% disagreed and 4.29% strongly disagreed. The correlation analysis shows that there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and past nuclear accidents ($r = -.188$, $p = .000$). Accidents from nuclear energy such as the Fukushima nuclear disaster, Japan in March 2011; Chernobyl nuclear accident, Ukraine, USSR in April 1986, and Three Mile Island disaster, the United States of America in March 1979, have been considered as one of the critical factors influencing public opinions in accepting nuclear technologies for power generation as a viable choice for electricity supply. The results show past nuclear accidents play a role in the the public wanting to understand and being curious about nuclear energy. Furthermore, the acceptance of nuclear technologies for power generation can be related to past nuclear accidents which shows the public's interest in accidents and hazards as potential risk factors (Misnon et al. 2017; Park 2019).

N13 – Distrust

The results observed show there is distrust among the political elites and the masses on the use of nuclear power generation as a viable option to generate power. Of the respondents, 28.39% strongly agreed, 47.91% agreed, 6.99% of the respondents were undecided, 13.47% disagreed and 3.24% strongly disagreed as illustrated in Table 3. The correlation analysis results show that there is a statistically significant but weak negative relationship between nuclear power generation as a viable option and distrust among the political elites and the masses ($r = -.131$, $p = .000$). The result shows there are fragmented trust issues between the political elites and the masses, which range from the inclusiveness of the public values when decisions are made on nuclear power generation, to the supply of education and information that the the public require about building nuclear power generation facilities. The result demonstrates these factors can lead to distrust (agree: 47.91%; disagree: 13.47%) among both parties (political elites and the masses), since the masses early involvement or decision-making was not considered, thereby destroying the openness and transparency of nuclear power generation as a viable option for electricity supply (Kovacs, Eng, and Gordelier 2010).

N14 – Finance

The results show that despite the high capital cost of a nuclear power project and time overruns associated with nuclear related projects, a total of 66.32% of the respondents agreed that financing the costs of nuclear power generation was viable by the government and a worthwhile investment. Only 11.26% of the respondents were undecided, 11.57% disagreed, and 10.84% strongly disagreed as illustrated in Table 3. Correlation analysis results indicate that there is a statistically significant but weak positive relationship between nuclear power generation as a viable option and financing the project ($r = .283$, $p = .000$).

N15 – Create additional employment opportunities

A high percentage of respondents suggested the building of a nuclear power generation plant may create additional employment opportunities in the country since 41.42% strongly agreed, 30.86% agreed, 8.05% of the respondents were undecided, 9.94% disagreed, and 9.73% strongly disagreed as observed in Table 3. The correlation analysis results show that there is a strong positive statistically significant relationship between nuclear power generation as a viable option and the creation of additional employment opportunities ($r = .559$, $p = .000$). The huge support for nuclear power as a source of employment can be attributed to the high unemployment levels in the country. According to the National Bureau of Statistics, the unemployment rate in Nigeria at the end of the third quarter of 2018, stood at an alarming 23.1% (NBS 2018). Thus, it is clear that Nigerians are on the lookout for all sources of employment opportunities for the teeming unemployed youth.

N16 – Support for electricity supply solution

From the result observations, a high percentage (44.67%) of the respondents strongly agreed that nuclear power generation was an alternative solution to the electricity supply problems experienced in the country, 30.33% agreed, 6.49% of the respondents were undecided, 10.56% disagreed and 7.95% strongly disagreed as illustrated in Table 3. The correlation analysis indicates that there is a strong positive statistically significant relationship between nuclear power generation as a viable option and support as an alternative solution to electricity supply ($r = .582$, $p = .000$). Overall, the result is not surprising as many Nigerians are increasingly relying on electricity for many of their basic energy services such as entertainment and cooking. Given the present unreliable power supply in the country, support for nuclear deployment in the country could have been conceived from the fact that nuclear power will increase the generation capacity of the existing electricity mix and thus, would improve the reliability of power supply, which, in turn, could potentially mitigate electricity tariffs. The support for nuclear power generation is not new in the country and this has been canvassed by many authors in the past (Dioha 2020).

N17 – Location of nuclear power generation plant

From Table 3, it is again observed that over 50% of the respondents agreed that the location of nuclear power generation plant is critical to the integration of electricity production from nuclear power plants in Nigeria, while just over a quarter of the respondents disagreed with the premise of the importance of location. However, less than a fifth of the respondents remained undecided on the pertinence of siting of the nuclear power generation plant. The results show that there is a strong positive statistically significant relationship between nuclear power generation as a viable option and the location of the nuclear power generation plant ($r = .531$, $p = .000$). The result thus indicates that many Nigerians are not very skeptical about the location of a nuclear power plant in the country.

Conclusion and recommendations

Studies on public perceptions of nuclear power generation in Nigeria are limited. In this paper, we examined the perception of the Nigerian public towards nuclear power generation as a source of energy in Nigeria, using a survey technique and relevant data analysis tools. This paper, through a quantitative method of representative sampling of Nigerians, determined the perceptions of Nigerians to nuclear energy as it affects the location of a nuclear generation plant, climate change, environmental challenges and disposal of nuclear waste, the skills needed to manage nuclear projects, infrastructural challenges, finances and the opportunities available from nuclear generation.

Considering the broader picture of the Nigerian public's sentiments, a reliable electricity supply is presently seen as a challenge to which nuclear power could be a potential solution. Nigerians also believe that nuclear power will ameliorate the huge unemployment facing the country by creating jobs during the period of power plant construction and due to the overall resulting economic stimulus. However, Nigerians remain skeptical of and restrain their support for nuclear power owing to the perceived risks due to previous nuclear accidents in other parts of the world as well as the inability of the Nigerian government to cope with nuclear waste, factors that are further fuelled by distrust between the people and the government. In terms of socio-political factors, the respondents agree that political unrests and increased insurgency attacks are likely constraints to building nuclear power generation plants due to potential damage and destruction of facilities.

Looking ahead, knowledge is power. Increased knowledge of nuclear power generation contributes to increased levels of acceptance. It is evident from the study results that there is a need to educate Nigerians about the potential benefits and challenges to nuclear power. This action will go a long way to improving the trust of the people in the government. The Nigerian government can achieve this through an intensified orientation using its agencies such as the National Orientation Agency as well as mainstream and social media outfits. This action will also reduce the negative aspects people hear about nuclear power, and thus, reduce the resistance to the deployment of the technology in Nigeria. Society's engagement is also needed in Nigeria's nuclear journey. People tend to be more trustworthy when they are part of a project. Consequently, the Nigerian government needs to engage its citizens from planning to commissioning stages of potential nuclear power plants to make it easier for Nigerian citizens to accept the technology.

In terms of the effective use of the study for theory and policy – our analysis provides a foundation for the Nigerian government to know where policy interventions are most needed for the smooth deployment of nuclear power in the country, such as in mass public education, technological safety, and political economy, among others. It is therefore imperative for the Nigerian government and other stakeholders in the energy industry to ensure that the perceptions of Nigerians towards nuclear generation are reflected in their strategies in improving the electricity challenges in Nigeria, especially as they work towards achieving the objectives of the National Energy Masterplan to promote and develop 1 GW of nuclear power by 2025.

Our study is not without limitations. The current research depended on descriptive and inferential statistics, which allow us to draw conclusions only on the field data collected. Future research could address this issue by using more robust techniques. While admitting this limitation, we believe that our findings provide the foundation for a debate on nuclear power deployment in Nigeria.

Disclosure statement

The authors declared that they have no conflicts of interest in this work. We declare that we do not have any commercial or associative interest that represents a conflict of interest in connection with the work submitted.

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Appendix A

1. Do you think electricity supply is a serious problem in Nigeria?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
2. Do you think Nuclear power is a viable option to solve the problem of electricity supply in Nigeria?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
3. Do you know about climate change and its causes?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
4. Do you think nuclear power can help to mitigate climate change?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
5. Do you think radioactive waste disposal can be a barrier to nuclear energy as an electricity generation option in Nigeria?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
6. Do you think political unrest and increased insurgency in Nigeria can make the use of nuclear energy to generate electricity dangerous?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
7. Do you think the skills to respond promptly in the case of accident will be a problem to nuclear power option in Nigeria?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
8. Do you think Nigeria inadequate maintenance culture can affect the use of nuclear energy to generate electricity?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
9. Do you think Nigeria environmental challenges can affect the use of nuclear energy to generate electricity?
   O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
10. Do you think Nigeria infrastructural challenges (e.g. bad roads, and inadequate railways) can affect the use of nuclear energy as option for electricity power generation (e.g. in transportation of nuclear energy materials and waste disposal)?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
11. Do you think negative media can affect the use of nuclear energy to generate electricity power in Nigeria?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
12. Do you think past nuclear accidents can affect the support of nuclear energy to generate electricity power in Nigeria?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
13. Do you think distrust among the political elites and the masses in Nigeria can affect the use of nuclear energy to generate electricity in Nigeria?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
14. Do you think Nigeria can finance a nuclear energy project to generate electricity?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree

15. Will you support the use of nuclear energy to generate electricity in Nigeria if it will create additional employment?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
16. Will you support the use of nuclear energy to generate electricity in Nigeria if it will solve Nigeria energy problem?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree
17. Will you support the use of nuclear energy to generate electricity in Nigeria if the nuclear plant were to be built in your state?
    O Strongly Disagree **O** Disagree **O** Undecided **O** Agree **O** Strongly Agree