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A study of stakeholders' perspectives to inform management of the development of a civil nuclear power program for electricity generation in Ghana

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Abstract: The renewed interest in the development of the civil nuclear power program in Ghana has since seen the implementation of sensitisation and educative programs aimed at enhancing knowledge and ensuring buy-in. A compendium of activities constituting stakeholder engagement efforts was conducted since the establishment of the Ghana Nuclear Power Programme Organization (GNPPO). A survey was piloted to measure, the perception, knowledge and interest of a section of the Ghanaian society. The results provided indications to expect that the nationwide survey will make evident, the high dependence on the national grid and appreciable interest for additional capacity (mainly solar and nuclear) to the existing electricity generation mix. Although participants are aware of some adverse effects of the power application of nuclear energy, the majority would likely be willing to accept the inclusion of nuclear power in Ghana's electricity generation mix and advocate for that endeavour.

Keywords: perception; knowledge; interest; nuclear; electricity.

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Adolf Kofi Awua holds a PhD in Public Health (Epidemiology), an MPhil and BSc in Biochemistry and Diploma in Human Resource Management. Additionally, he is a student of MA Bioethics program, planning to graduate in Fall 2021. He had additional training in research methods, research integrity, cancer prevention and other areas of biomedical sciences. With these and over the course of the past about 20 years he has worked in the research industry starting as a teaching and research assistant and ending a graduate demonstrator at the University of Ghana in 2017. Thereafter, he joined an infectious disease research team at the Ghana Atomic Energy Commission in 2018 as an Assistant Research Scientist and have risen to the rank of Principal Research Scientist and the position of a Head of Department.

George Kofi Appiah holds an MPhil in Nuclear and environmental protection from the University of Ghana and a BSc in Chemistry from the Kwame Nkrumah University of Science and Technology. He is currently an assistant research scientist and coordinator for Stakeholder and industrial Involvement for Ghana's nuclear power program at the Nuclear Power Institute of the Ghana Atomic Energy Commission. As a research scientist, George has been involved in the measurement of organic chemical residues and Persistent Organic Pollutants in the environment. He has participated in a number of projects both local and international and has had extensive training in the area. At the Nuclear Power Institute, George has been involved in the Identification and engagement of a wide range of Stakeholders for Ghana's nuclear power program. Activities in this regard has included public education and sensitisation using various tools and media, the conduct of surveys to measure public perception as well as industry appraisal to determine the capacity of local Industries. He has been trained in Stakeholder involvement for nuclear power programs.

Elikem Kwaku Ahialey holds a BSc Chemistry and Postgraduate Diploma in Education from the University of Cape Coast Ghana; an MPhil Nuclear and Radiochemistry and MA in Communications Studies, from the University of Ghana. He is a Research Scientist and Communicator. In research, he specialises in groundwater resources assessment using hydrochemical and isotopic techniques. In communications, he specialises in Nuclear Power Communication. He is an industrious, meticulous and result-oriented individual, with a passion for teaching, research and public relations issues. He

has participated extensively in IAEA-organised training programs such as 'Training on Uranium Recovery from Phosphates and Phosphoric'; 'Application of Isotopes and Modelling in Groundwater and Surface Water Management'; 'Training on Comprehensive Introduction to Nuclear Power'; and 'Application of Isotopes Modeling in Groundwater and Surface Water Management'.

1 Introduction

Ghana is a Sub-Saharan African country bordered on the north by Burkina Faso, on the west by Côte d'Ivoire, and on the east by Togo. The country had some power challenges in the past especially in the recent past which led to the inclusion of thermal power generation capacities to support power production from its hydropower plants. As of August 2020, the total installed capacity for existing plants in Ghana is 4132 Megawatt (MW), consisting of hydro 38%; thermal 61%; and solar less than 1% (GCCG, 2020). The high margin of thermal capacity in Ghana's energy mix does not only add to the country's contribution to greenhouse gas emissions but also appreciably results in a high cost of power and hence making industries uncompetitive.

As a result of these compelling reasons, the need to diversify the electricity generation portfolio by introducing more reliable, stable and clean energy sources has emerged and the campaign for nuclear power is ongoing.

Nuclear energy is not new to Ghana. The journey began with Ghana's first president's strong conviction, evident in a statement made in his speech on the day of laying the foundation stone of Ghana's Atomic Reactor Centre. He said, "We have therefore been compelled to enter the field of atomic energy because this already promises to yield the greatest economic source of power since the beginning of man".

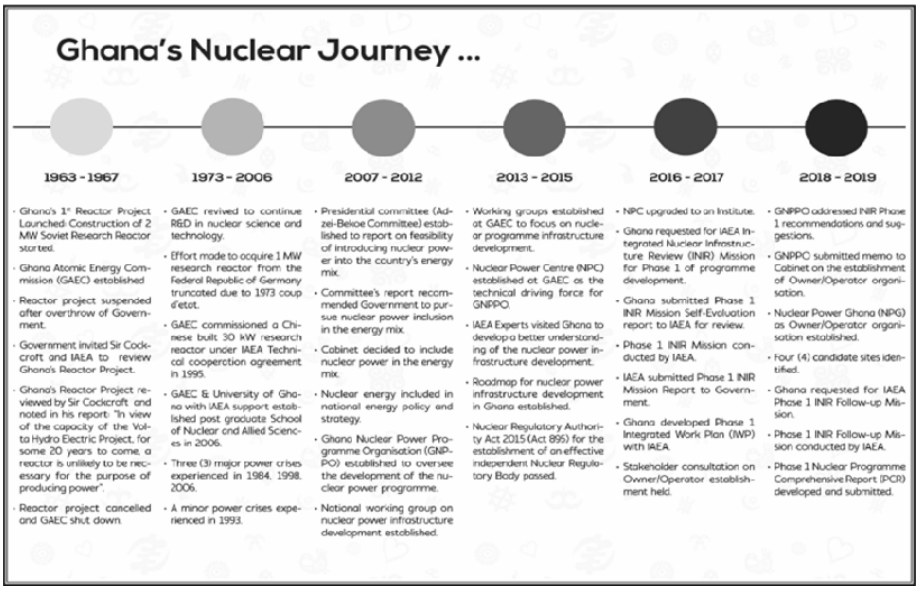
1.1 Renew interest in Ghana's nuclear power program

As part of efforts to fashion out possible ways to achieve a sustainable and resilient energy regime in Ghana, discussions of nuclear energy were revisited firstly through the establishment of the School of Nuclear and Allied Sciences (SNAS) in 2006 to enhance capacity building in the field. The Ghana Atomic Energy Commission and the University of Ghana jointly established the School of Nuclear and Allied Sciences and provided faculty, with the collaboration of the International Atomic Energy Agency (IAEA). SNAS became an IAEA Human Resource training Centre of Excellence for English speaking African Countries, just three years after its establishment.

The government in the year 2007 also set up a Committee to explore nuclear energy for electricity generation as a natural progression in the country's technological advancement. Subsequently, a nuclear power policy was developed as part of the Committee's work. Since then, nuclear has been a major policy option for Ghana's energy mix. The renewed interest in Ghana's nuclear power program has also resulted in the establishment of the Ghana nuclear power programme Organisation (GNPPO) and its technical body, the Nuclear Power Institute, the establishment of the Nuclear Regulatory Authority (NRA) through the passage of the Nuclear Regulatory Act, 2015 (Act 895) and recently, the Nuclear Power Ghana (NPG) as owner-operator organisation.

Phase I of Ghana's nuclear power program development which was based mainly on the IAEA milestone approach, saw the development of 19 infrastructural issues as captured in the IAEA Nuclear Energy Series (NG-G-3.1 (Rev. 1), 2015). As part of the Phase 1 implementation, Ghana requested an Integrated Nuclear Infrastructure Review (INIR) Mission in December 2015 and submitted a self-evaluation report (SER) to the International Atomic Energy Agency (IAEA) in March 2016. A pre-INIR Mission was subsequently conducted and the INIR Mission was conducted from 16–23 January 2017 in Accra. The main objective of the INIR mission was to assist Ghana to evaluate and determine the current status of the implementation of the nation's nuclear power program by reviewing the 19 infrastructure issues for phase 1 of the program based on the evaluation conditions prescribed by the IAEA. The outcome of the international peer-review conducted during the INIR mission as clearly specified in Ghana's INIR Phase 1 Mission Report (2017) was the provision of 12 recommendations, 8 suggestions, some of which were targeted at Phase 2 program implementation and also 3 good practices that were identified in the strategic approach adopted by Ghana in its program development. A program comprehensive report (PCR) which is a decision-making blueprint that details, a critical assessment of all the 19 infrastructural issues as well as recommendations as part of phase 1 was presented to the Cabinet in 2020. Figure 1 shows the journey so far in developing Ghana's nuclear power program.

Figure 1 Ghana's Nuclear Journey



1.2 Drivers of power application of nuclear in Ghana

Nuclear energy brings a long list of tangible benefits to any nation. Clean and reliable energy and access to electricity at predictable and affordable pricing over a long period boosts economic growth, private sector, entrepreneurship, education and science and even leads to the creation of new industries (IAEA Webinar Series No.3, 2019). Developing a civil nuclear capacity in Ghana is hinged on several considerations which

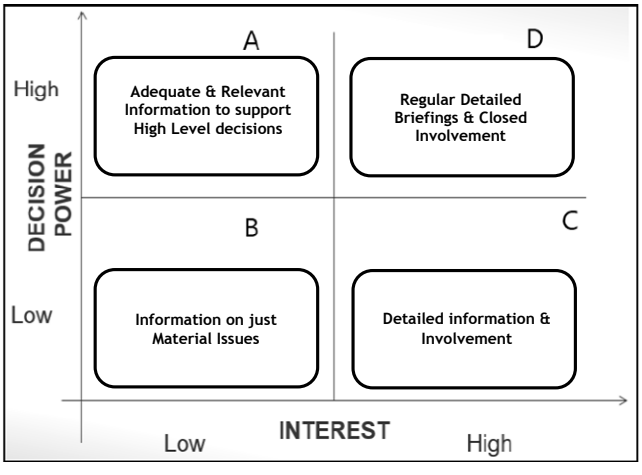
are reported in a published paper titled, the drivers of nuclear energy inclusion in Ghana's energy mix (Debrah et al., 2020). It suffices to highlight that, the major factors influencing Ghana's drive for nuclear power are the long-term vision outlined in Ghana's development plan with emphasis on, increasing demand for electricity and limited hydro as well as gas resources, the need for the diversification of energy source to make Ghana's energy portfolio much more resilient to ensure the security of supply, climate change mitigation, and industrialisation (economic diversification and transformation).

1.3 Involving stakeholders in Ghana's nuclear power program

Public perception of risk associated with projects involving the use of radioactive materials and their impact on the environment influence the decision-making process for such projects. Today it is generally acknowledged by those involved in nuclear power programs that, stakeholders have an important role and that the needs and interests of stakeholders should be taken into account to serve the mutual interest of society. As a result, a requirement for developing a sustainable infrastructure to support the overall feasibility of nuclear power programs is early and appropriate stakeholder involvement based on the principles of openness and transparency. Effective stakeholder involvement addresses concerns early and explains the nuclear power program's rationale, plans and progress (NG-G-3.1 (Rev. 1), 2015).

Stakeholder involvement in Ghana's nuclear power program is therefore well enshrined on such basis as, early and continuous involvement to effectively deliver on scope, cost and schedule, identifying, mapping and prioritising stakeholders, ensuring the accountability principles of inclusivity, materiality and responsiveness in an open and transparent atmosphere, monitoring and evaluating engagement inputs and outputs, feedback and reporting mechanism and building trust. Three key parameters that informed the mapping of stakeholders in the stakeholder involvement planning were institutional mandate, interest and influence and the electricity value chain. Figure 2 shows stakeholder categorisation based on interest and influence which impacts resource utilisation in promoting the nuclear power program.

Figure 2 Stakeholder categorisation on interest and influence



Acknowledging and addressing the expectations and concerns of the public is a key ingredient in the overall plan of involving stakeholders. These needs and expectations are identified through effective monitoring and feedback mechanisms that are built in the process. Feedback mechanisms enable the program to effectively evaluate engagement activities, retailer and redirect engagements based on a set of new stakeholder requirements collected.

The communication strategy of Ghana's program seeks to encourage cooperation and promote understanding between experts, decision-makers, and other members of the stakeholder communities to ensure technically sound and socially acceptable decision that meets norms of adequacy or satisfactory performance in relation to a whole range of varying stakeholder concerns. The objective of the program's communication is to provide background information to support decision making, provide general information about the nuclear power program and its objectives and also provide specific information to targeted stakeholders to enhance understanding and secure buy-in. These messages are delivered during media discussions and interviews, focus group discussions, summits, exhibitions, workshops, town hall meetings and lectures and they are mostly conveyed through traditional and social media publications and newsletter papers. The utmost objective of the nuclear power program campaign is to ensure the creation of a well-informed society that is appropriately positioned to provide knowledgeable support for the nation's nuclear power program.

To help measure the attainment of this objective, an evaluation of the impact of sensitisation and education efforts throughout the phase 1 implementation of Ghana's nuclear power program was planned and conducted in various ways. Opinion polls which are deemed crucial for evaluating the performance and impact of communication and educational activities in nuclear power programs and also, a potent resource for building and measuring societal inclination and trust were conducted.

1.4 Objectives

Clean and affordable energy occupies a very central position in the nexus of the sustainable development goals (SDGs) such that, increasing access to clean and affordable energy leads to achieving almost all of the SDGs – from poverty eradication via advancements in health, education, water supply and industrialisation to mitigating climate change. Investing in a variety of technologies to provide clean and affordable energy in all countries will not only increase access but also guarantee the energy security that is required for the achievement of the SDGs. Central to the attainment of the SDGs are civil society organisations (CSOs) whose role, the Ghana nuclear power program considers pivotal in the discussion and implementation of the program. The objective, therefore, is to openly and transparently arm CSOs with information considering firstly, their baseline positions which were assessed in this study.

Aside from the conduct of CSOs assessment, a survey was piloted in the Great Accra region and conceived to serve as a general guide to a future nationwide survey and also direct actions for the continuous rollout of the civil nuclear power campaign in Ghana. It was to determine existing knowledge, perception and interest in nuclear energy and applications and was the first step in meeting the IAEA recommendations from the first peer review of Ghana's nuclear power program.

This paper presents some indicators from data collected from stakeholders engaged in the phase 1 implementation of the nuclear power program.

2 Methodology

2.1 Assessment of the perspectives of some civil society organisations on Ghana's Nuclear program

Civil society organisations were identified and selected based on their mandates on achieving the SDGs, especially in the areas of clean energy, climate actions, environment, industrialisation and economic growth and their relatedness to achieving the objectives of Ghana's nuclear power program.

Selected CSOs were engaged through a series of workshops that included pre-engagement surveys and post engagement evaluations. The pre-engagement surveys were conducted in the following major areas among others,

1 general Knowledge about nuclear energy

2 knowledge of nuclear energy applications in Ghana

3 inclination to include nuclear power in Ghana's energy generation mix

4 position on the siting of nuclear power plant for electricity generation at an allowable distance from the respondent's settlement.

2.2 Pilot survey

2.2.1 Design and review of questionnaire

A survey questionnaire was developed and reviewed jointly by a team from the Ghana Statistical Service and the Nuclear Power Institute. The International Atomic Energy Agency (IAEA) also supported the process by providing an expert review of the questionnaire developed. The questionnaire was designed with a focus on some relevant aspects that were supposed to help measure stakeholder position. The principal elements considered in the pilot survey were consistent with those used in the CSOs' pre-assessment, namely, Electricity use, demand and reliability; Safety of nuclear energy applications; Inclusion of nuclear power in the energy mix and Siting of the nuclear power plant.

2.2.2 Targeted participants

The pilot survey which considered the adult population within the Greater Accra region of Ghana used a purposive sampling method that selected a study location where persons who were considered to be the 'most likely' to be 'well informed' among the public were to be met. These specifically included persons who were, media professionals, technical staff of industry, CSOs, educationists, students, legal practitioners, civil servants, health workers as well as staff of security agencies. These groupings constituted the study population in the pilot survey.

A convenience method was then used to recruit respondents from among the study population and a person was considered eligible if he/she was 18 years or older. Those who consented to participate, after receiving an explanation of the survey and its objectives, had the questionnaire administered to them.

2.2.3 Administration of questionnaire

The questionnaire was partly self-administered by students on internship who were trained to carry out this exercise and were supervised by research assistants and also partly through the public relations units of some prioritised institutions. Follow-ups were made to these institutions to collect the completed questionnaires for data input, processing and analysis.

2.2.4 Data management

Data collected were transferred to an MS Excel datasheet, validated and cleaned. The data were described with frequency tables, pie charts and bar charts. Cross tabulation was used to describe the relationship between responses. Percentages were calculated mostly as intension-to-treat.

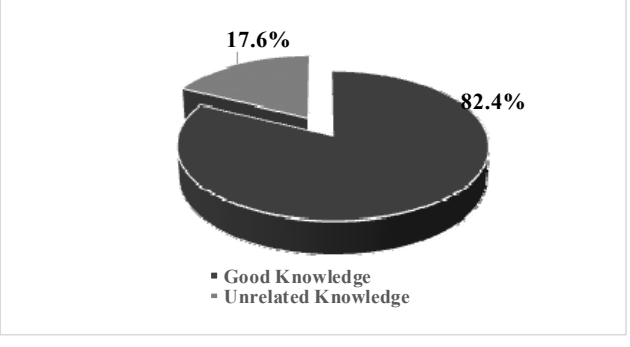
3 Results and discussions

3.1 Perspectives of some civil society organisations on Ghana's nuclear program

A total of 34 of the 40 different Civil Society Organisations identified in the areas of, SDG 7 (Affordable and Clean Energy), SDG 13 (Climate Actions), SDG 8 (Decent Work and Economic Growth) and SDG 9 (Industry, Innovation and Infrastructure) participated in the survey.

It was evident from the data that, a majority of the CSOs (82.4%) expressed a good level of knowledge (be it favourable – positive or unfavourable – negative), on nuclear energy (Figure 3). A small proportion of CSOs expressed knowledge that is unrelated to the subject area. Conversely, a majority (79.4%) of the CSOs expressed an inappropriate level of knowledge of the applications of nuclear energy in Ghana (Figure 4).

Figure 3 Distribution of proportions of CSOs on 'level of Knowledge in Nuclear Energy'



The majority (76.5%) of the CSOs were of the opinion that nuclear power should be included in the nation's energy mix. The distribution of the opinions of the remaining CSOs is depicted in Figure 5. In respect of siting of a nuclear power plant at an allowable

distance from human settlement, a majority (70.6%) of the CSOs were of the opinion that it was allowable while 20.6% of the remaining would not allow the construction of such a facility (Figure 6).

Figure 4 Distribution of the proportions of CSOs on 'level of Knowledge in Nuclear Energy Applications in Ghana'

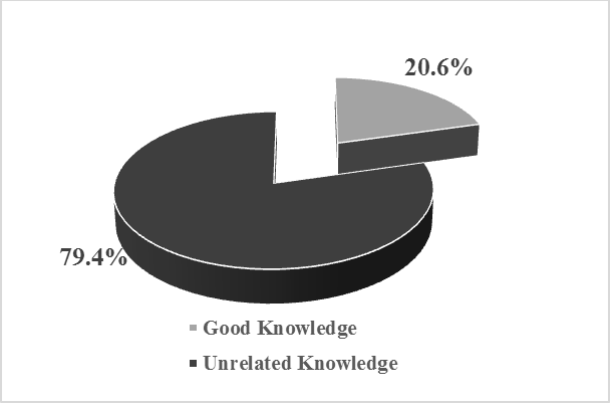


Figure 5 Distribution of CSOs opinion on 'the Inclusion of Nuclear Power into Ghana's Energy Mix'

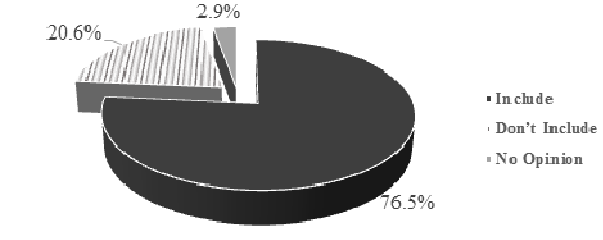
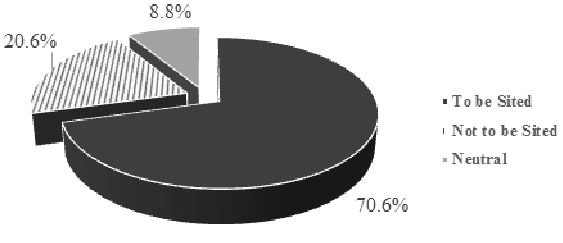


Figure 6 Distribution of the opinion of CSOs on 'the Siting of Nuclear Power Plant at Allowable Distance away from human settlement'



The civil society organisations that participated in the survey were more inclined to the inclusion of nuclear power in Ghana's energy mix and the siting of the facility at an

allowable safe distance from their settlement albeit with some proposed conditions precedent. These considerations are, ensuring safety and security in the management of the nuclear power facility, ensuring effective training of personnel and maintenance culture, and abiding thoroughly with regulations and laws governing the operation of the facility. The CSOs also supported their positions on including nuclear power by indicating such basis as, reduction in energy deficit and tariff, stable, reliable and cheap power to support industry and generate employment. Others also based their non-acceptance on potential health implications to citizens and the environment and also potential nuclear accidents.

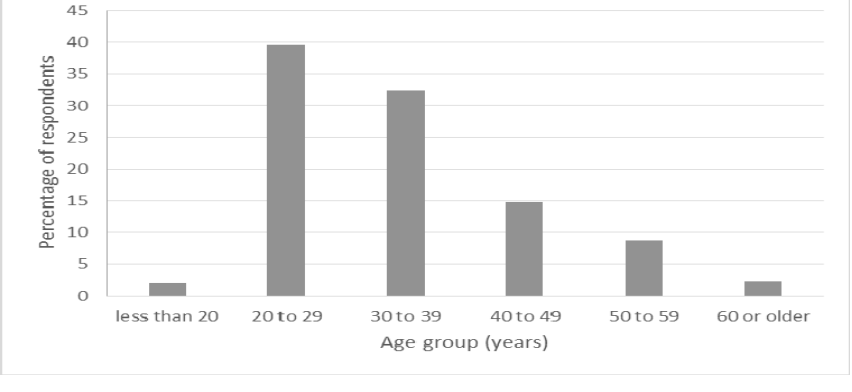
3.2 Perspectives from pilot survey

A total of 650 questionnaires were rolled out using the two modes of questionnaire administration described in the method section. The overall questionnaire return rate was found to be 78.5%. The second mode of administration was identified to hold up 21.5% of the total questionnaires rolled out.

3.3 Demographic data

Of the 510 persons who participated in this survey, 398 provided information on their age. The average age of the respondents to this survey was found to be 33.6 ±10.8 years within a range of 18 years to 70 years. As depicted in Figure 7, the two age groups that were mostly represented among the respondents were 20–29 years (39.7%) and 30–39 years (32.4%). The chart shows reducing participation for the older age groups considered.

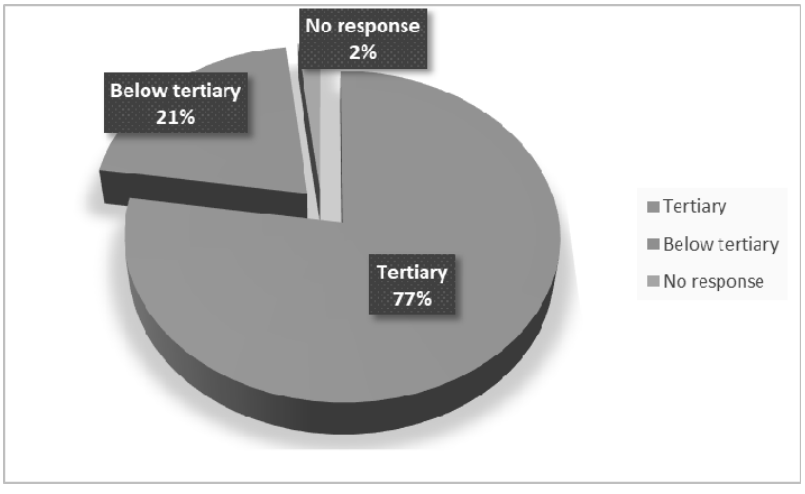
Figure 7 Age distribution of the respondents of the survey



The distribution of the sex of the participants showed that a higher proportion of males (63.3%) than females (36.3%) took part in the survey. Although the survey was conducted in the Greater Accra Region, 18.5% of participants indicated they were residents in other regions of the country.

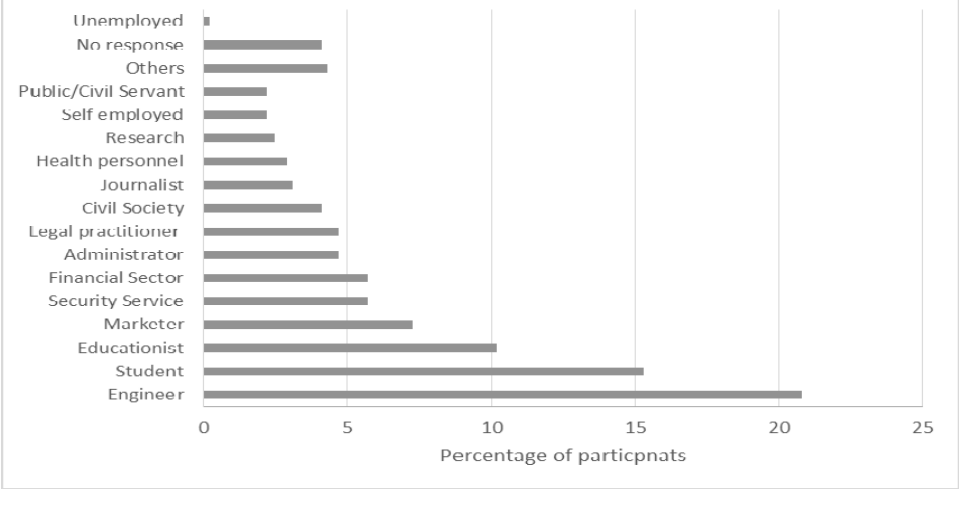
The educational level of the participants was dichotomised and was distributed as follows tertiary (77.5%), and below tertiary 20.8%. The remaining 1.5% did not indicate their educational level (Figure 8).

Figure 8 Distribution of the educational level of participants



Respondents indicated diverse occupations which were then categorised to support data evaluation. The distribution is presented in Figure 9. The highest proportion of respondents was in the field of engineering, recording 20.8%. Students and Educationists were the next highest occupational areas accounting for 15.3% and 10.2% respectively. Each of the remaining twelve occupational areas identified accounted for less than 10.0% of the survey participants.

Figure 9 Distribution of the occupational areas identified among surveyed participants



3.4 Analysis of principal elements of survey

3.4.1 Electricity use

Predominantly (95.3%) of the respondents indicated that the national electricity grid was the main source of electricity used in their households. This result is supported by the

very high access to grid electricity of about 84% in 2019 (Macrotrends, 2020–2021) in Ghana, than present in other countries in the sub-region.

However, generators and solar energy sources were also indicated as the main electricity sources for 1.96% and 1.56% of the respondents respectively (Table 1). Additionally, for the majority (94.9%) of the respondents, electricity was either highly important (82.7%) or important (12.2%) for their household activities. Among the remaining respondents, 3.7% indicated that electricity was somewhat important whilst 0.6% indicated it was less important.

Table 1 Distribution of respondents' main source of electricity use

Household use of electricity	*Main Source of electricity, n (%)*					
	Generator	*National grid*	*No response*	*Other*	*Solar*	*Grand total*
Do not use	0	1	0	0	1	2
Uses	10	485	2	4	7	508
Grand total	10 (1.96)	486 (95.3)	2 (0.39)	4 (0.78)	8 (1.56)	510

In response to actions to improve the availability of electricity in Ghana, respondents provided 1398 suggestions. The commonest theme (26.2%) among the given suggestions was "Get other sources of electricity to complement existing ones (mostly Solar and Nuclear)". Among the other nine themes formulated from the suggestions (Table 2), "Eliminate waste in electricity generation and distribution" (10.2%) and 'Block illegal connections' (9.9%) were the next most common themes. The survey further investigated which other source of energy the participants perceived will best address Ghana's challenges with electricity generation. A greater proportion of the response (63.1%) indicated solar generation as the other source that will be helpful to the Ghanaian situation. The next most perceived source was Nuclear energy, with 21.4% of the responses. Interestingly, none of the respondents stated coal as a viable source for electricity generation to help solve Ghana's challenges (Figure 10) although it was part of the options provided as possible answers to this question.

Figure 10 Distribution of electricity generation options perceived acceptable for Ghana

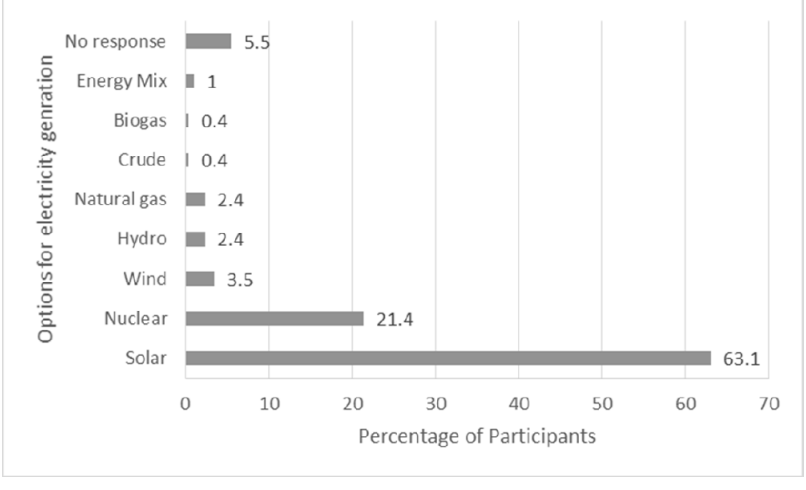


Table 2 Thematic categorisation of suggested actions for the improvement of electricity availability in Ghana

Actions suggested to improve electricity availability in Ghana	*Frequency*	*Percentage*
Get other sources to complement existing ones (mostly solar and nuclear)	368	26.3
Eliminate waste in electricity generation and distribution	143	10.2
Block illegal connections	138	9.9
Replace dilapidated equipment with new ones	117	8.4
Adequate funds be provided	74	5.3
Desist from corrupt practices	2	0.1
Ensure and Improve upon proper management efficiency	2	0.2
Educate users on how to conserve more than wasting it	1	0.1
Every year, at least, government should add 10% of installed capacity to the national grid	1	0.1
Improve efficiency of existing plants	1	0.1
No response	24	1.7
Total responses	1398	100.0
Total respondents	510	

A majority of the respondents (89.4%) claimed they had heard about nuclear energy while some others stated they had not heard about nuclear energy (8.0%) while 2.5% of participants did not respond. Among those who indicated they had heard of nuclear energy, the leading sources of awareness stated were the internet and television; these were indicated 228 and 129 times, respectively, out of the 671 times that a source was stated. Following a cross-tabulation with the educational levels of the respondents, it was noted that the post-secondary educational level had the highest proportion of respondents (96.2) who had heard of nuclear energy. The educational level with the next highest proportion of respondents who have heard of Nuclear energy was the Tertiary level (89.9%). The distribution of the awareness of nuclear energy and source of information on nuclear energy stratified by educational levels are shown in Table 3.

Further, in stating anything participants knew about nuclear energy, 76.6% of the participants indicated their areas of knowledge (Figure 11). The commonest stated area (by 33.7% of the participants) was the power application of nuclear energy. The other areas included nuclear reactions and radiation (20.9%), safety concerns (11.0%), and weapon manufacture (7.5%). As much as 20.3% of the participants stated areas that clearly were misinformation.

In response to knowledge of specific issues related to the application of nuclear energy in Ghana, 138 (27.0%) of the participants indicated they had knowledge of the application of nuclear energy in the Ghanaian economy (Figure 12). Of these, 42.0% indicated their knowledge of the application of nuclear energy in the Ghanaian health sector; 19.0% indicated its use in the industrial sector and 16.0% in the agricultural sector. Figure 13 depicts the full distribution of the sectors mentioned by the participants in the present survey. Additionally, in soliciting answers on whether electricity generation with nuclear energy is environmentally friendly, 42.0% of the participants indicated their responses in the affirmative whereas, 17% of them did not indicate their knowledge.

Table 3 Awareness of nuclear energy, sources of the awareness and their distribution among participants with different levels of education

	*Frequency, n (%)**								
	JHS/JSS/MSLC	*Vocational/Technical*	*Secondary*	*Post-secondary*	*Tertiary*	*Other*	*No response*	*Total responses*	*Total respondents,*
Heard of Nuclear energy	3 (60.0)	6 (75.0)	5 (71.4)	51 (96.2)	355 (89.9)	26 (92.9)	10 (71.4)		456 (89.4)
Internet	0	3	0	31	173	15	6	228	
Television	1	2	1	10	105	8	2	129	
Radio	1	1	1	9	62	3	1	78	
Print media	0	0	1	8	73	7	1	90	
A friend/relative	1	1	2	7	28	2	1	42	
School	1	0	2	4	51	2	0	60	
Conference/ forum/workshop	0	0	0	1	15	1	0	17	
Work	0	0	0	1	8	1	0	10	
GAEC	0	0	0	1	5	0	0	6	
No response	0	0	0	1	9	1	0	11	
Total responses	4	7	7	73	529	40	11	671	
Not Ever heard of Nuclear energy	2 (40.0)	2 (25.0)	1 (14.3)	1 (1.9)	31 (7.8)	2 (7.1)	2 (14.3)		41 (8.0)
No response	0	0	1 (14.3)	1 (1.9)	9 (2.3)	0	2 (14.3)		13 (2.5)
Column total	5	8	7	53	395	28	14		510

Figure 11 Distribution of the respondents' areas of knowledge on nuclear energy

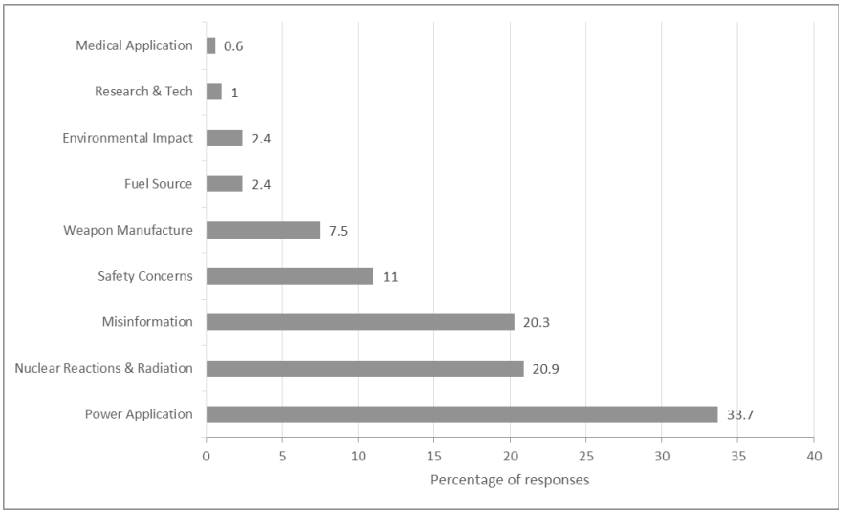


Figure 12 Distribution of knowledge on 'the use of nuclear energy in the Ghanaian economy'

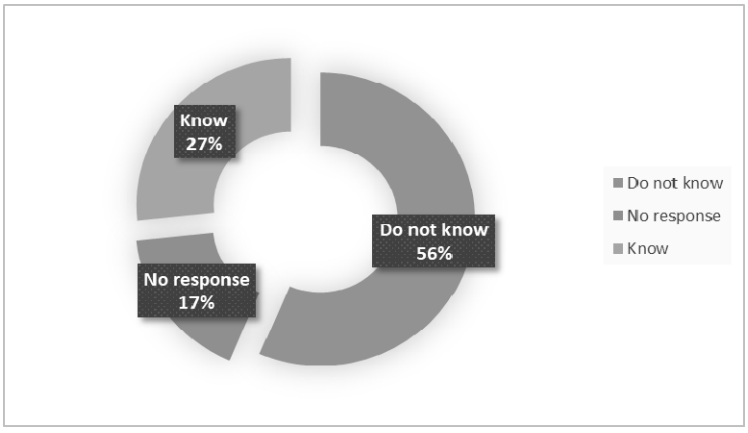
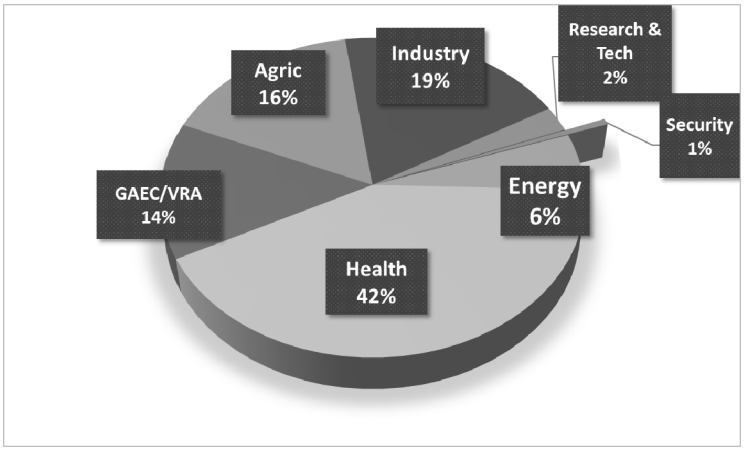


Figure 13 Distribution of knowledge of participants on 'sectors of nuclear energy applications in Ghana'



Regarding participants' knowledge of adverse effects of the use of nuclear energy, 45.0% indicated their knowledge. However, only 42.4% were able to indicate their specific knowledge, 22.0% did not respond and 12.0% were not sure of what they knew. Among those who stated their specific knowledge, 15.3% stated unrelated facts. However, 21.5% stated concerns about radiation exposure and related effects, 16.4% indicated concerns about cancer and other health effects and 11.3% stated effects due to accidents and related death. Figure 14 provides the detail of the distribution of the stated adverse effects.

3.4.2 Perception of nuclear energy

Further investigation of the perception of the participants in respect of whether the adverse effects they stated were manageable, showed that 37.0% of the participants were of the view that the effects were manageable, while 7.0% stated that the effects they

stated were not manageable. The remaining participants stated they did not know if these effects were manageable (17.0%) whiles others also did not provide any response (Figure 15).

Figure 14 Distribution of participants' opinion on adverse effects associated with the use of nuclear energy

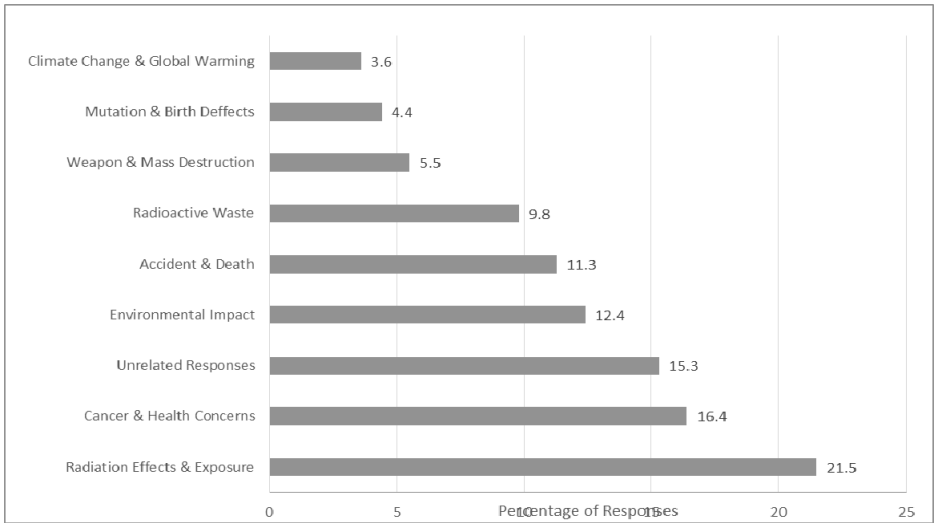
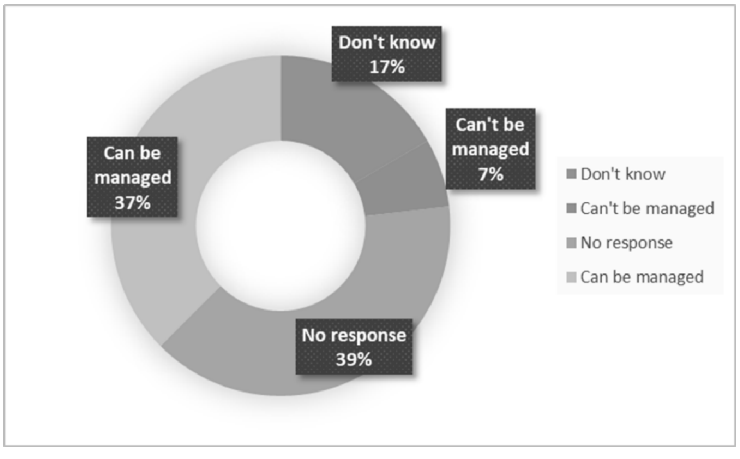
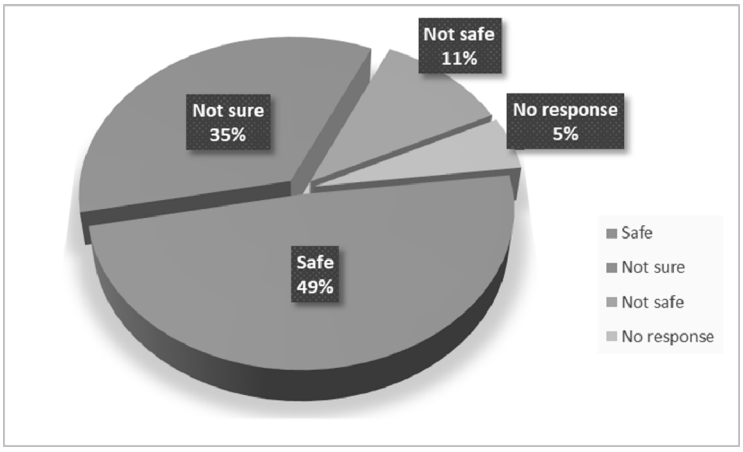


Figure 15 Distribution of participants' perception on 'whether stated adverse effects were manageable'



Despite the adverse effects provided by participants in their responses, 49.0% of the respondents perceived nuclear energy as safe for the generation of electricity (Figure 16). However, as much as 35.0% of the participants were not certain of their perception of this issue, and 5.0% did not respond. The remaining 11.0% indicated they perceived nuclear energy for electricity generation as unsafe.

Figure 16 Distribution of participants' perception on 'the safety of nuclear energy for electricity generation



3.4.3 Acceptance of siting and advocacy for nuclear power plant

The relationship between some concerns and possible actions by the participants that have the potential to influence the success of the nuclear power program was assessed. It was observed from a cross-tabulation that amongst the 56 participants that had the perception that nuclear energy was not safe for electricity generation, 67.9% ($n = 38$) stated they will not accept the siting of a nuclear power plant at a safe and allowable distance from their community, while 12.5% ($n = 7$) were not sure if they will accept the sitting. Conversely, 19.6% of the participants who perceived nuclear energy as not safe stated they will accept the sitting of the nuclear power plant at a safe and allowable distance from their community (Table 4). On the other hand, a converse relationship was also observed when 18.5% ($n = 46$) of the 249 participants who perceived nuclear energy for the generation of electricity as safe stated that they will not accept the siting of nuclear power plant at a safe and allowable distance from their community. Further converse relationships with the acceptability of siting a nuclear power plant were noted among the participants who either were not sure of their perception or did not respond (Table 4). A consistent relationship was expressed by 163 of the 249 participants (65.5%) who perceived nuclear energy for electricity generation as safe, indicating that they will accept the sitting of a nuclear power plant at a safe and allowable distance from their community. Overall, 49.8% and 23.5% of the 510 participants of this survey indicated they either will or will not accept the siting of a nuclear power plant at a safe and allowable distance from their community respectively.

The relationship between acceptance of nuclear power plants in Ghana's energy mix and the acceptance of siting the nuclear power plants at a safe and allowable distance from a particular community was also assessed and the findings are presented in Table 5. The findings showed that 76(14.9%) participants will not accept nuclear power plants in Ghana's energy mix, and 48 (63.16%) indicated they will not accept the siting of same at a safe and allowable distance from their community. However, 9 (14.9%) of them although indicated they will not accept nuclear power plants in Ghana's energy mix also stated they will accept the siting of a nuclear power plant at a safe and allowable distance from their community. Another indication of a converse relationship between these

perspectives was shown by 65 (16.62%) of the 391 participants who stated they will accept nuclear power plant in Ghana's energy mix but will not accept the siting of the nuclear power plant at a safe and allowable distance from their community.

Table 4 Relationship between perceived safety and acceptance of sitting of NPP in a community

Acceptance of siting of NPP	*Safety of Nuclear for electricity generation, n (%)*[*]				*Total (5)*[#]
	Not safe	*No response*	*Not sure*	*Safe*	
Will not accept	38 (67.9)	4 (14.8)	32 (18.0)	46 (18.5)	120 (23.5)
No response		18 (66.7)	5 (2.8)	6 (2.4)	29 (5.7)
Not sure	7 (12.5)	2 (7.4)	64 (36.0)	34 (13.7)	107 (21.0)
Will accept	11 (19.6)	3 (11.1)	77 (43.3)	163 (65.5)	254 (49.8)

Table 5 Relationship between acceptance of NPP in Ghana's energy mix and acceptance of sitting of NPP in a community

Acceptance of siting of NPP	*Acceptance of NPP in Ghana's energy mix, n (%)*[*]			*Total (%)*[#]
	Will not accept	*No response*	*Will accept*	
Will not accept	48 (63.16)	7 (16.28)	65 (16.62)	120 (23.5)
No response		21 (48.84)	8 (2.05)	29 (5.7)
Not sure	19 (25.00)	10 (23.26)	78 (19.95)	107 (21.0)
Will accept	9(11.84)	5 (11.63)	240(61.38)	254(49.8)
Total (%)[^]	76 (14.9)	43 (8.4)	391(76.7)	510

[^]Percentage: total for each column of acceptance in mix relative to grand total.

[#]Percentage for total for each acceptance of siting relative to grand total.

*Percentage of each cell of acceptance in mix relative to its column total.

Consistency in these perspectives was indicated by 240 of the 391 participants who stated they will accept nuclear power plants in Ghana's energy mix and will accept the siting of same in their community. It is also interesting to note that although some of the participants did not state their perspective on the acceptance of nuclear power plants in Ghana's energy mix, they indicated whether they will or will not accept a nuclear power plant in their communities. Some participants were neutral regarding both perspectives. Overall, 76.7% of the 510 participants stated they will accept nuclear power plants in Ghana's energy mix. Following the indication of their willingness to accept nuclear power plants in Ghana's energy mix, the participants further indicated the concerns that informed their acceptance or otherwise and went on to indicate if they were willing to advocate for the inclusion of nuclear in Ghana's energy mix. Table 6 shows that 57 participants had concerns regarding the capacity to manage the nuclear power plant, however, 52 of them representing 91.2% were willing to advocate for the inclusion of nuclear. Of the 42 participants who had concerns related to the cost of funding, 32 (76.2%) were willing to advocate for the inclusion of nuclear in the mix. Similarly, a majority of the participants 91.3% and 87.2% who had concerns about the maintenance

of the facility, and safety and security respectively, were willing to advocate for the inclusion of nuclear in Ghana's energy mix. Overall, 419 of the 510 participants (82.2%) were willing to advocate for the inclusion of nuclear in Ghana's energy mix.

Table 6 Relationship between concerns about and the willingness to advocate for the inclusion of NPP in Ghana's energy mix

	Major concern for including nuclear power in Ghana's energy mix, n(%)[*]						
	Capacity to manage	*Cost of funding*	*Maintenance of facility*	*Safety and security*	*Other*	*No response*	*Grand total (%)*[#]
Will not advocate	3(5.3)	8(19.0)	4(8.7)	33(10.1)	1(2.8)		49(9.6)
No response	2(3.5)	2(4.8)		9(2.7)	28(77.8)	1(100.0)	42(8.2)
Will advocate	52(91.2)	32(76.2)	42(91.3)	286(87.2)	7(19.4)		419(82.2)
Grand total (%)[^]	57(11.2)	42(8.2)	46(9.0)	328(64.3)	36(7.1)	1(0.2)	510

^Percentage: total for each column of major concern relative to grand total.

[#]Percentage for total for each willingness to advocate relative to grand total.

[*]Percentage of each cell of major concern relative to its column total.

The relationship between the participants' willingness to advocate for the inclusion of nuclear power in Ghana's energy mix and their willingness to work at a nuclear power plant was also evaluated. The findings as presented in Table 7 showed that, of the 419 participants who were willing to advocate for the inclusion of nuclear power, 223 (53.2%) were willing to work at the facility should it be available while 186 were not willing to. On the other hand, of the 49 participants who stated they will not advocate for NPP, 44 (89.8%) indicated they are not willing to work at a nuclear power plant should it be available; the remaining 5 (10.2%) stated they are willing to work at a nuclear power plant should it be established. Overall, 238 (46.7%) and 231 (45.3%) of the participants of this survey were not willing and willing to work at a nuclear power plant.

Table 7 Relationship between willingness to advocate for the inclusion of NPP in Ghana's energy mix and the willingness to work in an NPP

	Advocate for NPP, n (%)[*]			
Work at NPP	*Will advocate for NPP*	*Will not advocate for NPP*	*No response*	*Grand total (%)*[#]
Will not work at NPP	186 (44.4)	44 (89.8)	8 (19.0)	238 (46.7)
Will work at NPP	223 (53.2)	5 (10.2)	3 (7.1)	231 (45.3)
No response	10 (2.4)	0.0	31 (73.8)	41 (8.0)
Grand total (%)[^]	419 (82.2)	49 (9.6)	42 (8.2)	510

^Percentage: total for each column of major concern relative to grand total.

[#]Percentage for total for each willingness to advocate relative to grand total.

[*]Percentage of each cell of major concern relative to its column total.

4 Conclusions

The surveys were conceived to offer general guidance to future actions targeted at creating a more informed and receptive society for the success of the nation's nuclear power program.

It can clearly be stated that, the outcomes of the surveys presented in this paper show very appreciable acceptance potential relative to the non-acceptance potential of the nation's nuclear power program. Although this is a positive indicator of the potential success of Ghana's nuclear power program, there is the need to enhance promotional activities to further reduce misinformation and non-acceptance potential as evident in the surveys.

It is noteworthy that participants in these surveys were persons considered to be the 'most likely' to be 'well informed' among the public. Hence their positive perception, knowledge and interest as evident in the pilot survey is an advantage to the promotional efforts of the nuclear power program which include, a positive impact on the sensitisation drive, shaping of public interest and promoting the objectives of Ghana's nuclear power program.

It is important that targeted engagement with the category of CSOs expressing unrelated knowledge be implemented to help improve their understanding and properly position them to make meaningful inputs into the program development. More so, broader stakeholder engagement through targeting all categories of stakeholders is crucial to identifying the specific needs of stakeholders for information.

References

Debrah, S.K., Nyasapoh, M.A., Ameyaw, F., Yamoah, S., Allotey, N.K. and Agyeman, F. (2020) 'Drivers for nuclear energy inclusion in Ghana's energy mix, (Nov. 2020), Hindawi', *Journal of Energy Volume 2020*, 12 pages.

Ghana Country Commercial Guide (GCCG) (2020) August, https://www.trade.gov/country-commercial-guides/ghana-energy-sector

IAEA Energy Series No. NG-G-3.1 (Rev. 1) (2015) *Milestone in the Development of a National Infrastructure for Nuclear Power*, pp.1–7.

IAEA Mission Report on the Integrated Nuclear Infrastructure Review (INIR) – Phase 1 (2017) Counterpart: Ghana Nuclear Power Programme Organization (GNPPO), 16–23 January, 2017, Accra Ghana, pp.7–9, https://www.iaea.org/sites/default/files/documents/review-missions/inir-mission-to-ghana-january-2017.pdf

IAEA Webinar Series No.3 (2019) Stakeholder Involvement Related to Nuclear Power, Public Information Centres, Opening the Doors; Maximising the Benefits of Public Information Centres, December.

Macrotrends (2020–2021) https://www.macrotrends.net/countries/GHA/ghana/electricity-access-statistics, 2010 – 2021, LLC.