PERCEPTIONS IN NAIROBI COUNTY TOWARDS NUCLEAR ELECTRICITY GENERATION IN KENYA

BY

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DECLARATION

This paper is my original work and has not been submitted for examination for any other course or to any other university.

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This paper has been submitted for examination with my approval as the university supervisor.

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ABSTRACT

Electricity demand in Kenya has grown steadily over the years and the trend is expected to continue. The country's electricity is currently generated using renewable energy resources and fossil fuels. Nuclear electricity has been taken into consideration in the country's energy planning as a potential source of electricity in the long-term. Nuclear technology used for electricity generation is capable of safely producing large amounts of reliable electricity at relatively low prices. Public acceptance is one of the prerequisites for successful introduction of nuclear electricity in the country. The public's perceptions towards nuclear electricity generation are shaped by, among other things, the potential benefits and risks of the technology. This study sought to determine the public's perception of nuclear electricity generation in the country and to investigate the factors that influence their perception. The study based its statistical analyses on a logit model and used it to deduce the public's perception of nuclear electricity as well as the relative importance of each of the explanatory variables in influencing their perception. The study relied on primary data collected using a questionnaire administered to 96 respondents in Nairobi County. The study found that majority of the respondents (70.83%) supported the inclusion of nuclear electricity in the country's energy mix in the long-term with a minority (29.17%) rejecting it. The study also found that a number of factors namely age, knowledge about nuclear electricity, remedies and timing played a role in shaping the public's perception. These factors therefore ought to be factored in during design and implementation of initiatives by the Government aimed at gaining acceptance of the technology. The Government's stakeholder involvement initiatives ought to be tailored towards creating awareness through adequate knowledge dissemination to the public, particularly among the younger generation. The Government ought to also create public forums through which it can engage different stakeholders in the nuclear electricity programme and get their views so as to ensure sustainability of policy decisions regarding the programme.

CHAPTER ONE

1. INTRODUCTION

1.1. Background to the Study

Energy has been identified as one of the key contributing factors to civilization. It has resulted in significant changes in economies and transformed countries around the world. The changes in the economies have resulted in diversification of sources of energy in order to continue meeting the perpetual rise in demand for energy. These changes over time have led to the discovery of new forms of energy and invention of new technology to harness that energy (World Economic Forum, 2013).

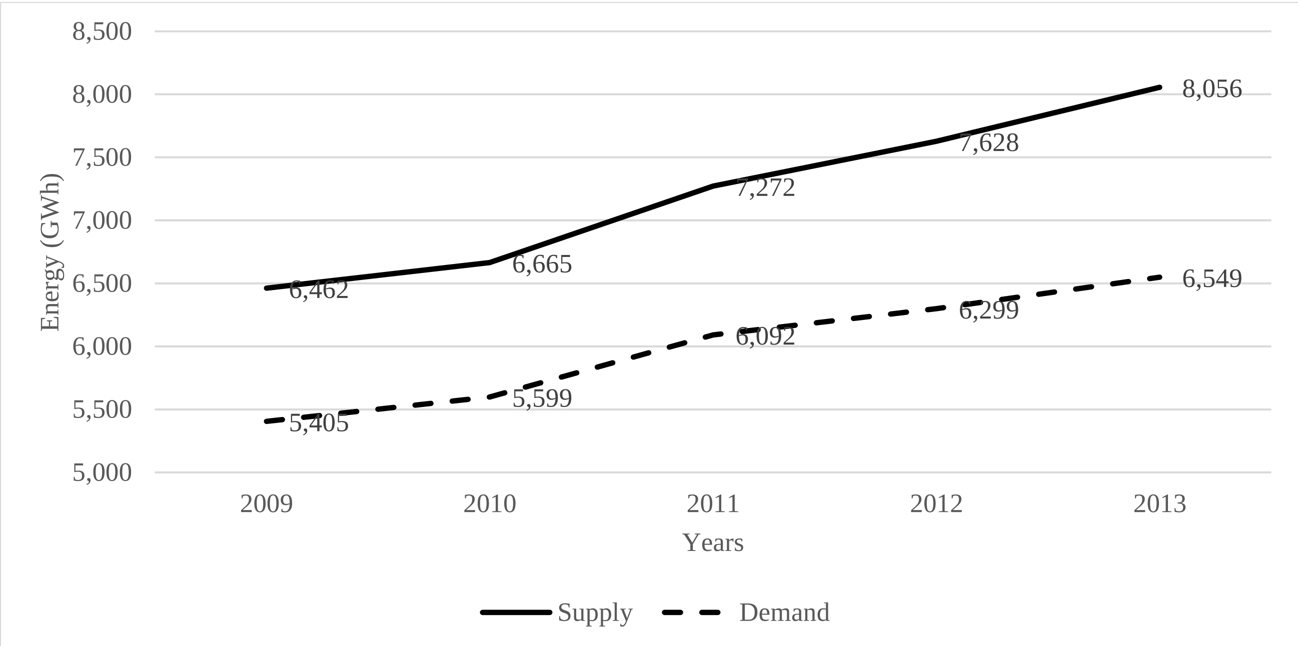
A country's energy mix with regard to electricity generation is determined by its geography and resource endowment. This mix varies from country to country. For example, the share of coal in electricity generation in the United States was 48% in 2007 and this has declined to about 36% in 2013. Natural gas on the other hand has seen its share expand from 19% in 2005 to 31% in 2013. Nuclear, coal and natural gas contribute approximately 25% each to Europe's energy mix. Electricity in China is generated mainly from coal (80%) and hydropower (16%) (World Economic Forum, 2013).

Kenya's energy requirements are met by biomass, petroleum and electricity. Biomass accounts for about 69% of the overall energy supply, petroleum accounts for about 22% and electricity accounts for about 9%. Electricity in the country is generated using renewable energy sources as well as fossil fuels and these sources of energy contributed to 69% and 31% respectively of the total generation as at December 2014 (Ministry of Energy and Petroleum, 2015). Natural energy sources available in the country for exploitation comprise hydro, geothermal, coal, biomass, biogas, cogeneration, tidal waves, solar and wind.

1.2. Demand for Electricity in Kenya

There has been steady growth in demand for electricity in the country. The peak demand in 2013/14 was 1,463 megawatts (MW) and this was an increase from 1,236 MW in 2011/12 (Ministry of Energy and Petroleum, 2014). Figure 1 illustrates the balance between electricity demand and supply from 2009 to 2013. The total energy supplied during the period rose from 6,462 gigawatt hours (GWh) in 2009 to 8,056 GWh in 2013 while the total energy consumed rose from 5,405 GWh to 6,549 GWh. The total system losses grew from 16.4% to 18.6% (Ministry of Energy and Petroleum, 2014).

Figure 1.1. Electricity demand and supply balance (2009 – 2013).



Source: Ministry of Energy and Petroleum (2014).

The growing demand for electricity can be credited to a number of reasons namely normal growth, increased connections in both urban and rural areas as well as the country's goal to transform itself into a newly industrialized country (Ministry of Energy and Petroleum, 2014).

The country's development blueprint, Kenya Vision 2030, seeks to transform Kenya to a newly industrialized country providing a high quality life to all its citizens by the year 2030 (Government of Kenya, 2007). The Vision's strategies, which aimed at achieving an average gross domestic product growth rate of 10% per annum beginning in 2015, are being implemented through flagship projects. The proposed flagship projects have added to the increase in the country's demand for energy in general and electricity in particular.

The demand for electricity is also expected to rise as county governments continue to be established and operationalized. It is anticipated that economic activities will expand within the counties thus increasing the demand for electricity. Energy-intensive activities such as mining, production of iron and steel, irrigation of land, operation of petroleum pipelines, production of petrochemicals as well as electrification of designated rail lines will also bring about an increase in electricity demand (Ministry of Energy and Petroleum, 2015).

1.3. Status of Electricity Generation in Kenya

Electricity in Kenya is generated using renewable energy sources and fossil fuels. Renewable energy is harnessed from naturally occurring resources that are constantly replenished and which include geothermal, hydro, solar and wind. Fossil fuels on the other hand are depletable resources and they include petroleum, coal and natural gas (Ministry of Energy and Petroleum, 2015).

Kenya's energy mix has largely been dependent on hydroelectricity which accounted for 38% of the electricity generated in 2014 (Ministry of Energy and Petroleum, 2015). Hydroelectricity is susceptible to changes in climate and rainfall patterns thus when the rains fail, a shortage in electricity supply is experienced. Thermal electricity generation accounts for 32% of the electricity supplied in the country with thermal power plants being located in various parts of the country (Ministry of Energy and Petroleum, 2015). Fluctuations and instability in international fuel prices pose a challenge in the use of this source of electricity generation because increases in the price of fuel make thermal electricity generation expensive.

Energy plays a key role in the manufacture of products and therefore the cost of energy is directly related to the cost of the products including the costs of other factors of production. The price of electricity in Kenya is high and unpredictable particularly when the amount of thermal electricity in the electric power system is large. This is because thermal electricity generation is affected by changes in the international prices of oil. Furthermore, the quality of the electricity supplied to industries is wanting owing to fluctuations and interruptions (Kenya Association of Manufacturers, 2012).

Energy is essential in the process of industrialization. Adequate and affordable energy supply is a prerequisite for any country that seeks to industrialize. Kenya’s energy costs are relatively high. The country’s electricity tariff was 9.4 US cents per kilowatt hour (kWh) in 2008. Comparatively, the electricity tariffs of Kenya’s major competitors in trade and services, South Africa and Egypt, were 6.6 US cents per kWh and 3 US cents per kWh respectively (Kenya Institute for Public Policy Research and Analysis, 2010). The country ought to produce more energy at low costs and increase efficiency in energy consumption. New sources of energy will be discovered through exploitation of geothermal, coal, nuclear, renewable energy resources and interconnections with countries in East Africa that have surplus energy (Government of Kenya, 2007).

1.4. Consideration of Nuclear Electricity Generation

Nuclear electricity has been incorporated in Kenya's energy planning as a potential source of electricity generation in the long-term. Results of an energy planning study for the period 2011 to 2031 indicate that the total new additional capacity to the country's electric power system will be 18,920 MW. The additional capacity will consist of 5,040 MW from geothermal units, 2,400 MW from coal units, 2,000 MW from imports, 4,000 MW from nuclear units, 2,340 MW from gas turbines, 1,440 MW from medium speed diesel units, 1,500 MW from wind units and 200 MW from hydro units (Ministry of Energy, 2011).

Nuclear power plants generate heat through a process called fission. The heat turns water into steam which drives steam turbines connected to electric generators and electricity is produced. Uranium atoms are split in a nuclear reactor and this process (fission) generates the heat needed to produce steam. There were 438 operational reactors operating in 31 countries and 70 reactors under construction in 15 countries as at December 2014 (International Atomic Energy Agency, 2015).

Nuclear electricity has characteristics that make it a source of energy that is potentially viable for Kenya in the long-term. Nuclear fuel, which is required for operation of a nuclear power plant, can easily be stored and this helps a country to achieve energy security. Inclusion of nuclear electricity in a country's energy mix also assists in diversifying the country's energy sources (International Atomic Energy Agency, 2001). Nuclear power plants can help in maintaining long-term stability of electricity prices. This is despite their high capital investment requirement, including establishment of requisite organizations (International Atomic Energy Agency, 2001).

The activities that need to be completed in order to successfully introduce nuclear electricity can be divided into three progressive phases of development. In each phase, various issues require careful consideration. Stakeholder involvement is one of the issues to be considered in order to ensure success in the introduction of nuclear electricity in a country (International Atomic Energy Agency, 2007). It is important that involvement of the stakeholders in a nuclear electricity programme be based on openness and honesty between the different stakeholders in the programme. Information accessed by the stakeholders regarding the nuclear electricity programme should be relevant and forums ought to be created through which the stakeholders can air their views on the programme (International Atomic Energy Agency, 2007).

1.5. Research Problem

Kenya's development blueprint is anchored on, among other things, energy. Development projects recommended in the blueprint will increase demand for energy in the country. Electricity demand is also expected to rise as county governments take shape and economic activities accelerate in the counties. The country's peak demand was 1,354 MW in 2012/13 and is projected to grow to 15,026 MW by 2031 (Ministry of Energy, 2011). Nuclear electricity is considered as a long-term option in the country's energy mix. It was initially projected that the first 1,000 MW nuclear power plant would begin operating in 2022. Successful introduction of nuclear electricity in a country is dependent on, among others things, the public's acceptance of the nuclear electricity programme. The public's perceptions regarding nuclear electricity generation are shaped by, among other things, the potential benefits and risks of the technology. This study sought to determine the public's perception of nuclear electricity generation in the country and to investigate the factors that influence their perception. This information is not available in spite of its importance in determining whether or not a nuclear electricity programme would take off in Kenya.

1.6. Research Questions

i. Would the public in the capital city of Nairobi accept nuclear electricity generation in Kenya?
ii. For the accepting population, what factors would influence their decision?
iii. For the rejecting population, what factors would influence their decision?
iv. What policy implications would arise from this study?

1.7. Research Objectives

Nuclear electricity has been considered for inclusion in the country's energy mix because of its potential to provide secure base load electricity at a lower price. The main objective of this study was to determine public perception of nuclear electricity generation in the country. The specific objectives of the study were:

i. To assess whether or not the public in the capital city of Nairobi would accept nuclear electricity generation in the country.
ii. To investigate the different factors that would shape the accepting population's decision.
iii. To investigate the different factors that would shape the rejecting population's decision.
iv. To draw policy on nuclear electricity generation in the country arising from this study.

1.8. Significance of the Study

Stakeholder involvement in a nuclear electricity programme seeks to create forums through which stakeholders can make their views on the programme known and work together with the Government to ensure that their views are considered accordingly. Stakeholder involvement is crucial in successfully developing the programme with regard to building confidence and trust, without which it will be difficult to make progress (International Atomic Energy Agency, 2011). It is important to note that proper stakeholder involvement improves the quality and sustainability of policy decisions.

This study sought to determine the public's perception of nuclear electricity generation. The country's nuclear power programme is in its initial phase of development. This study would therefore make a contribution in terms of providing advice to the Government with regard to a policy decision on whether or not to introduce nuclear electricity into the country's energy mix. It would also advise stakeholder involvement policies put in place by the Government towards gaining public acceptance for the programme. Furthermore, the study would serve as a basis for future studies on public acceptance of the programme by the Government and/or other stakeholders.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Theoretical Literature Review

Individuals' perception of risk comprises estimation of the probability that an event will occur and assessment of the extent to which they would be affected by the adverse consequences of such an event. Some of the models that have been used to explain people's risk perception include the psychometric paradigm and the cultural theory (Kilinc, Boyes, & Stanisstreet, 2013). The psychometric paradigm is the most dominant approach to studying risks. The paradigm has been instrumental in ascertaining the general structure of perceived risk held by most individuals and has been used to generate quantitative representations of risk attitudes and perception (Kim, Choi, & Wang, 2014).

The psychometric paradigm focuses predominantly on cognitive aspects that influence how individuals perceive risk (Rippl, 2002). The paradigm makes the assumption that what individuals subjectively understand as risk may be influenced by a wide array of psychological, social, institutional and cultural factors. The paradigm assumes that using an appropriately designed survey instrument, majority of these factors and their interdependence can be enumerated and modelled to gain a better understanding of individuals' and society's attitudes toward the hazards they face (Bronfman & Cifuentes, 2003). According to the paradigm, the intuitively perceived degree of riskiness is more important to individuals than the objectively estimated number of fatalities that might occur because of visible hazards. The psychometric paradigm assumes that the perception of risk is as a result of a combination of elements including voluntariness, dread, control, knowledge and catastrophic potential (Kilinc, Boyes, & Stanisstreet, 2013).

Despite its use in providing insight into how people respond to risk, the psychometric paradigm has also come under criticism. It has been criticized on the basis that it neglects social and cultural influences on risk perception (Rippl, 2002). The paradigm has also been criticized in relation to the instruments of quantitative investigation, in particular the inherent restrictions imposed by the questionnaire survey. The rating scales are defined by the researcher and this means that respondents are not able to point out what really matters to them about the issues being investigated (Bickerstaff, 2004).

The cultural theory on the other hand attempts to account more clearly for social, political and cultural factors. The theory argues that attitudes toward risk and danger differ systematically according to a few cultural biases or worldviews which can be identified in various contexts and societies (Bickerstaff, 2004). According to the theory, the most important predictors of what people choose to fear or not to fear are socially shared worldviews which determine the individual's perception (Rippl, 2002). The theory assumes that people's perception of risk is influenced by their cultural background which consists of deeply held beliefs and values that are themselves the result of different patterns of socialization (Kilinc, Boyes, & Stanisstreet, 2013). Nonetheless, the theory's assumption that how individuals perceive risk is informed by the imposition of wider cultural values on the individuals has been found to be questionable (Goodfellow, Williams, & Azapagic, 2011).

2.1.1. Public Acceptance of Nuclear Electricity Generation

Countries around the world are increasingly becoming concerned with issues pertaining to energy, particularly due to the rising and volatile prices of fossil fuels, security of energy supply and mitigation of climate change. Nuclear electricity generation is considered to be one of the suitable options in addressing these global concerns. However, the technology continues to be a contentious one as far as the public and their acceptance of it is concerned (Organization for Economic Co-operation and Development, 2010).

Literature on how nuclear electricity is perceived points to an enduring public concern in a majority of the countries that are introducing or expanding their nuclear electricity programmes. The Three Mile Island accident that occurred in 1979 and the Chernobyl disaster that occurred in 1986 together with concerns about management of nuclear waste have only served to reinforce public interest. During the period between the mid-1970s and early 1980s, nuclear power and radioactive waste were considered to be dreaded and unknown risks. This was because of their invisible and long-lasting effects, concerns regarding nuclear waste disposal and a historic association with nuclear weaponry (Parkhill, Pidgeon, Henwood, Simons, & Venables, 2010).

Generation of nuclear electricity in a country depends, to a large extent, on the willingness of the country's citizens (public) to host a nuclear power plant. Public acceptance of the power plant can be enhanced through assuring the public of nuclear safety, especially in the wake of the Fukushima Daiichi nuclear disaster which occurred in 2011 (Han, Kim, & Choi, 2014).

Proponents of nuclear electricity generation cite the technology's potential to lower greenhouse gas emissions as one of its benefits. However, the Fukushima Daiichi nuclear disaster has given prominence to concerns regarding nuclear accidents and management of radioactive waste (Davis, 2012).

The public's perception of nuclear electricity generally and nuclear safety specifically poses a major challenge for countries considering the use of nuclear technology for electricity generation. It is important for countries to prepare public communication and information plans as well as to involve different stakeholders in their nuclear electricity programmes so as to gain their acceptance of the programmes (International Atomic Energy Agency, 2009).

2.1.2. Potential Risks and Benefits of Nuclear Electricity Generation

Nuclear electricity generation is a topic that elicits diverse reactions from the public. Despite the prospective benefits of the technology, it also has risks such as safety of the nuclear power plant keeping in mind the nuclear accidents that have occurred, challenges associated with disposal of radioactive waste, economics of nuclear electricity and concerns regarding nuclear proliferation (Rogner, 2010).

The public's perception of nuclear electricity generation is influenced by their knowledge of the potential benefits and risks of the technology. Concerns regarding the management of radioactive waste and safe operation of the nuclear power plant are likely to prompt opposition to the technology while reduction in the cost of electricity and mitigation of climate change are likely to bring about support for it (Omata, Katayama, & Arimura, 2015).

Perceptions regarding nuclear electricity generation are shaped by, among others things, the potential benefits as well as risks of the technology. The public's arguments in support of and opposition to nuclear electricity generation are shaped by the available information on the technology (Hattingh & Seeliger, 2002). Arguments in favour of nuclear electricity are based on, among others things, its clean characteristic. Nuclear electricity generation does not produce carbon dioxide, nitrogen dioxide, sulphur dioxide and heavy metals. It therefore does not pollute the environment. Another argument in favour of nuclear electricity is that it is relatively affordable compared with other alternative sources of electricity.

Nuclear safety is one of the public's main concerns pertaining to nuclear electricity generation. Nuclear safety has to be guaranteed if acceptance for a nuclear electricity programme is to be gained from the public. The management of radioactive waste is also a major public concern (European Atomic Forum, 2014).

2.2. Empirical Literature Review

Numerous studies have been carried out across the world to analyze the level of public acceptance of nuclear electricity programmes in countries either introducing or expanding their programmes. The studies have also sought to determine the extent to which the likely benefits and risks of nuclear electricity have played a role in shaping the public's perceptions toward the use of nuclear technology for electricity generation.

Public acceptance of nuclear electricity can be influenced by individuals' level of knowledge about the nuclear technology used to generate electricity as well as their perceptions of the likely benefits and risks associated with nuclear electricity generation. South Africa has two operating nuclear power plants and is planning to expand its nuclear electricity programme. Results of a public opinion survey conducted in 2011 to examine the public's perception of nuclear electricity showed that South Africans are not very conversant with nuclear electricity generation. From the survey, 40% of the respondents could not indicate whether or not they were in support of nuclear electricity while 23% approved of it (Wyk, 2013). A similar study was carried out in South Korea to investigate the relative importance of psychological, sociological and political factors in understanding the public's perception of nuclear risk. The study showed that the perceived costs and benefits of nuclear electricity are strongly related with the perceived nuclear risk. From the study, increased perceived costs are linked to increased levels of perceived nuclear risk and increased perceived benefits are linked to reduced levels of perceived nuclear risk (Cha, 2004).

Support for nuclear electricity generation is driven by, among other things, mitigation of climate change. Generation of nuclear electricity does not pollute the environment and it is therefore a clean source of energy. A study carried out in Australia to probe the public's perception toward introduction of nuclear electricity as part of efforts to mitigate against climate change indicated that 42% and 34.4% of the respondents in 2010 and 2012 respectively supported the efforts (Bird, Haynes, Honert, McAneney, & Poortinga, 2014). The decrease in support for nuclear technology in 2012 was attributed to the Fukushima Daiichi nuclear disaster. Similarly, a study carried out in Japan to analyze the public's attitude toward the continued generation of nuclear electricity after the Fukushima Daiichi nuclear disaster indicated that more males compared to females as well as those who were more educated supported the continued use of nuclear technology as part of measures to prevent global warming (Arikawa, Cao, & Matsumoto, 2014).

Nuclear safety continues to be one of the main concerns that the public has about nuclear electricity generation. Guaranteeing nuclear safety is one of challenges facing countries that are introducing or expanding their nuclear electricity programmes. A study carried out in Nigeria to examine the public's perception regarding the benefits and risks of introducing nuclear electricity into the country's energy mix indicated that the public is opposed to nuclear electricity because of concerns relating to nuclear safety. 52.7% of the study's respondents were of the opinion that the risks associated with nuclear electricity outweigh the benefits (Akinmola, Osaghae, Abdulazeez, & Ahidjo, 2014).

2.3. Overview of Literature

The literature reviewed indicates that the research carried out on individuals' perception of risk has relied largely on the psychometric paradigm and the cultural theory to explain their risk perception. The psychometric paradigm is the most dominant approach and it assumes that perception of risk is influenced by a combination of factors that include voluntariness, dread, control, knowledge and catastrophic potential. The cultural theory on the other hand assumes that individuals' perception of risk is influenced by their cultural background which is made up of beliefs and values that are the result of different socialization patterns.

Successful introduction of nuclear electricity in a country is dependent upon, among other things, public acceptance. Nuclear electricity generation raises public concerns that mainly relate with ensuring nuclear safety and managing radioactive waste. Nonetheless, nuclear electricity has benefits that include reduction in electricity costs and mitigation of climate change. Studies carried out in countries either introducing or expanding their nuclear electricity programmes indicate that the potential benefits and risks associated with nuclear electricity generation play an important role in shaping the public's perception of it.

Nuclear electricity has been considered for inclusion in the Kenya's energy mix as a potential source of electricity in the long-term and from the literature reviewed, its successful introduction depends on, among others things, public acceptance. It would therefore be important to determine the public's perception of nuclear electricity generation in the country because this would have an implication on policies regarding the proposed nuclear electricity programme.

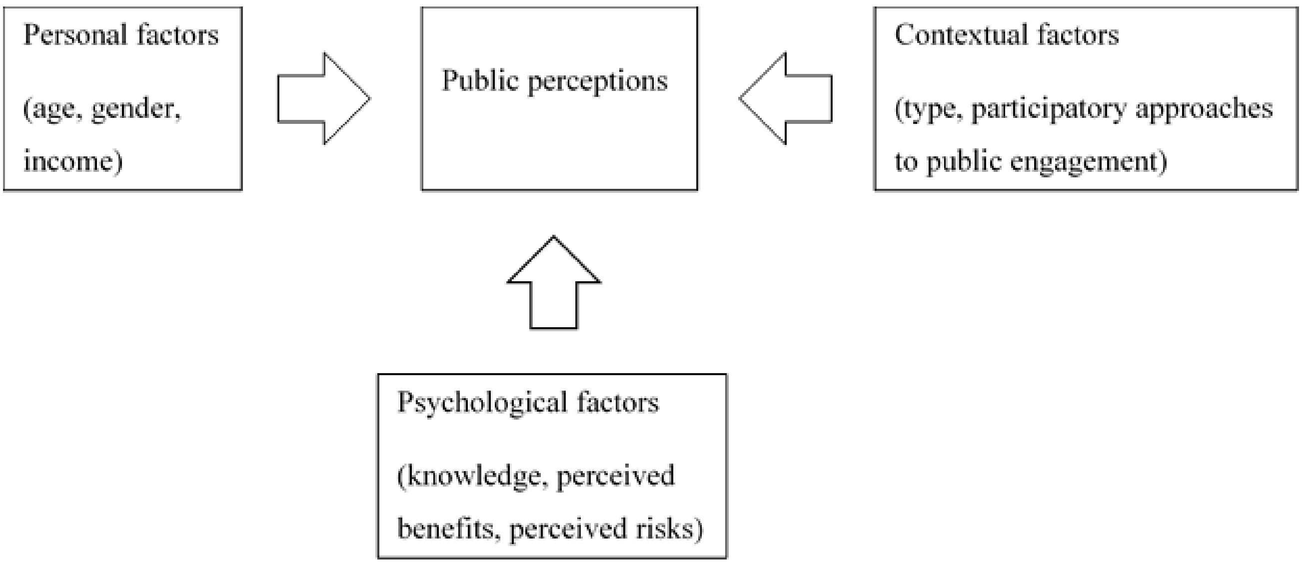
CHAPTER THREE

3. METHODOLOGY

3.1. Conceptual Framework

Literature strives to provide possible explanations for the public's perceptions of renewable energy technologies, including nuclear technology. Public perceptions can broadly be explained by factors that fall into personal, socio-psychological and contextual categories (Devine-Wright, 2007). Personal factors include age, gender and income; socio-psychological factors include knowledge, environmental and political beliefs; and contextual factors include technology type, scale and institutional structure. Figure 2 illustrates the interaction between the factors that strive to explain public perceptions toward renewable energy technologies.

Figure 2.1. Interaction of factors that influence public perceptions toward renewable energy technologies.



Source: Author, 2016.

3.1.1. Personal Factors

Personal factors consist of socio-demographic characteristics such as age, gender and income. Studies that have been carried out indicate that there exists a relationship between the level of acceptance of nuclear electricity generation and age. Older people tend to be more supportive of nuclear electricity than younger people. Results of the studies also indicate that women have higher preferences for nuclear electricity compared to men (Devine-Wright, 2007).

3.1.2. Socio-psychological Factors

Socio-psychological factors consist of degree of awareness and understanding, political beliefs as well as environmental beliefs and concerns. Studies that have been carried out on public acceptance of renewable energy technologies show that there is a relationship between knowledge level and acceptance of low carbon technologies, including nuclear technology. Findings of the studies also suggest that environmental beliefs and concerns, particularly relating to climate change, bring about support for nuclear electricity (Devine-Wright, 2007).

3.1.3. Contextual Factors

Low carbon technologies used for electricity generation (such as nuclear reactors, solar photovoltaic panels, wind turbines and hydro schemes) utilize different natural resources in different ways and the environmental, economic and social impacts of the technologies vary. As such, literature on public attitudes toward each of the technologies is dissimilar. Participatory approaches to public involvement in establishment, ownership and financial composition of electricity generation projects have been advocated for as part of efforts to minimize social conflict and gain public acceptance of the projects (Devine-Wright, 2007).

3.2. Model Specification

The public's perception of nuclear electricity is dependent on a number of factors. This study analyzed two out of the three broad categories of factors that influence public perceptions toward renewable energy technologies namely personal and psychological factors. From the literature reviewed, the factors that tend to influence the public's perception toward nuclear electricity include age, gender, knowledge about nuclear electricity and perceived benefits and/or risks of nuclear electricity. The relationship between the public's perception and the factors can be written as in equation 1.

$$y_i = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 \qquad (1)$$

where y_i represents the public's perception toward nuclear electricity; β_1, β_2, β_3 and β_4 represent unknown parameters; x_1 represents age; x_2 represents gender; x_3 represents knowledge about nuclear electricity; and x_4 represents perceived benefits/risks of nuclear electricity.

An econometric model for the study was obtained by introducing a random error term, e_i, in equation 1. The error term represented all the factors, other than those that have been considered in the model, that influence public perception toward nuclear electricity. Inclusion of the error term resulted in equation 2.

$$y_i = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + e_i \qquad (2)$$

The public's perception of nuclear electricity in this study was presented in terms of two possible responses from respondents thereby resulting in the use of a binary response model for the study. The dependent variable in this model were assigned numerical values of 0 and 1 as in equation 3. The numerical values did not indicate any natural ordering of the possible responses.

$$y_i = \begin{cases} 1 & Accept \\ 0 & Reject \end{cases} \quad (3)$$

There are two typical binary response models which specify different functional forms of the response probability as a function of the independent variables with the probability varying across respondents. These models are the logit and probit models (Cameron & Trivedi, 2005). Regression of a binary dependent variable models the probability $y_i = 1$ necessitating adoption of a nonlinear formulation as in the two models because they restrict the predicted values to be between 0 and 1. Probit regression uses the normal cumulative distribution function whereas logit regression uses the logistic cumulative distribution function (Stock & Watson, 2011). Both regressions often produce comparable results and the choice of one regression over the other is in some cases for mathematical convenience (Greene, 2012). Both the normal and logistic distributions have the accustomed bell shape of symmetric distributions (Greene, 2012).

The error term in this study was assumed to be symmetrically distributed as in equation 4.

$$Pr(y_i = 1|x_1, x_2, x_3, x_4) = Pr(-e_i = \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 | x_1, x_2, x_3, x_4) = F(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (4)$$

where F is the cumulative distribution function of $-e_i$, which equals the cumulative distribution function of e_i in the normal case of density symmetric about 0.

This study assumed a logistic distribution for the error term resulting in the use of a logit model. The logistic function of the logit model is given in equation 5.

$$Pr(y_i = 1|x_1, x_2, x_3, x_4) = \frac{exp(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4)}{1 + exp(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4)} = \Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (5)$$

where $\Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4)$ represents the logistic cumulative distribution function taking on values strictly between 0 and 1.

The binary response model that was used in this study is given in equation 6.

$$Pr(y_i = 1|x_1, x_2, x_3, x_4) = \Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (6.1)$$

$$Pr(y_i = 0|x_1, x_2, x_3, x_4) = 1 - \Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) \quad (6.2)$$

Equation 6 presents the anticipated relationship between the two possible responses of the dependent variable y_i (public acceptance or rejection of nuclear electricity) and the different independent variables. This study based its statistical analyses on the equation and used it to estimate the probabilities of the responses to deduce the public's perception of nuclear electricity as well as the relative importance of each of the independent variables in influencing their perception.

3.3. Estimation and Inference

Binary outcomes are ordinarily estimated by maximum likelihood because the distribution of the data is essentially defined by the Bernoulli model whose outcome is binomially distributed per trial (Cameron & Trivedi, 2005). The starting point for the estimation is to obtain the probability mass distribution function which specifies the density of y_i as in equation 7.

$$f(y_i|x_i) = p_i^{y_i}(1 - p_i)^{1-y_i}, \; y_i = 0, 1 \quad (7)$$

where $p_i = \Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4)$. This results in probabilities p_i and $1 - p_i$ because $f(1) = p^1(1 - p)^0 = p$ and $f(0) = p^0(1 - p)^1 = 1 - p$.

The density of y_i in equation 7 implies that the log density $\ln f(y_i) = y_i \ln p_i + (1 - y_i)\ln(1 - p_i)$. Taking equations 6.1 and 6.2 for p_i, the log-likelihood function for the study is provided in equation 8.

$$\ln L = \sum_{i=1}^{n}\{y_i \ln \Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4) + (1 - y_i)\ln[1 - \Lambda(\beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4)]\} \quad (8)$$

The $\hat{\beta}_i$, their standard errors and the value of the likelihood function are quantified in binary response analysis. The signs of the partial effects of each x_i on the response probability are given by the $\hat{\beta}_i$ (Wooldridge, 2010). Hypothesis tests for maximum likelihood estimators are performed using the *t*-statistic and 95% confidence interval levels since the estimators are normally distributed (Stock & Watson, 2011).

3.3.1. Measure of Fit

Models with binary dependent variables can be measured for goodness of fit using either the fraction correctly predicted or the pseudo-R^2. The rule used for the fraction correctly predicted is the following: if $y_i = 1$ and the predicted probability is greater than 50% or if $y_i = 0$ and the predicted probability is less than 50%, then y_i is said to be correctly predicted. The pseudo-R^2 on the other hand uses the likelihood function to measure the fit of the model. It does this by making a comparison between the value of the maximized likelihood function with all the explanatory variables and the value of the function with none of the variables (Stock & Watson, 2011). This study measured the goodness of fit of the model using the pseudo-R^2 because the fraction correctly predicted does not reflect the quality of the prediction despite being easy to understand.

3.3.2. Likelihood Ratio Test

The likelihood ratio test is centred on the difference between the log-likelihood functions for the unrestricted and restricted models. The notion behind the test is that dropping variables generally results in a smaller log-likelihood since the maximum likelihood estimator maximizes the log-likelihood function. A decision on whether or not the reduction in the log-likelihood is large enough to reach the conclusion that the dropped variables are important can be made once a test statistic and a set of critical values are obtained (Wooldridge, 2012). This study used the likelihood ratio test to test whether or not the coefficients in the model are equal to zero.

3.4. Sample Design

The target population for this study was the people in Nairobi County. This study based its statistical analyses on primary data collected from respondents in the county. The county had a population of 3,138,369 people in 2009 (Kenya National Bureau of Statistics, 2010).

Respondents for this study consisted of individuals aged 18 years and above. From the results of the 2009 census, individuals aged 18 years and above made up 65% of the county's population (2,039,198 people). Results of the census also indicated that the proportions of male and female individuals in this age bracket was 52% (1,068,591 people) and 48% (970,607 people) respectively (Kenya National Bureau of Statistics, 2010).

The calculation to determine an appropriate sample size for this study assumed a confidence level of 95% and a confidence interval of 10%. The following formula was used to calculate the sample size (Creative Research Systems, 2012).

$$Sample\ size\ = \frac{\frac{z^2\ \times p(1-p)}{e^2}}{1\ +\ \left(\frac{z^2\ \times p(1-p)}{e^2N}\right)}$$

where the z-score (z) used was 1.96, the margin of error (e) was 0.05, the population size (N) was 2,039,198 and the distribution (p) was 0.5.

The resulting sample size was 96. Data for the study was therefore collected from 96 respondents who were be selected using simple random sampling from the target population.

3.5. Data Collection

This study relied on primary data for its empirical analysis. The data was collected using a questionnaire administered to 96 respondents. The questionnaire was designed to collect information on the respondents' perceptions of nuclear electricity and the factors that tend to influence their perceptions as identified in this study. Prior to collecting data, a pilot study was carried out within Nairobi County to determine the effectiveness of the data collection instrument in obtaining the required information. Responses were sought from five respondents for the pilot study.

CHAPTER FOUR

4. DATA ANALYSIS AND DISCUSSION OF RESULTS

4.1. Descriptive Statistics

The specific statistics under consideration in this study were the means, standard deviations as well as minimum and maximum values. Most of the variables taken into account were binary in nature and hence only assumed values of zero and one. The study revealed that 70.83% of the respondents accepted the introduction of nuclear electricity in the country while 29.17% rejected it. Majority of the respondents therefore supported the inclusion of nuclear electricity in the country's energy mix in the long-term.

The age variable in this study was a categorical variable with the respondents' age having been classified into four categories. Majority of the respondents were in the 18 to 23 years category while those aged above 60 years were the least. The male respondents constituted 54.17% of the sample and the female respondents constituted 45.83% with a variation of about 50%.

The study revealed that 77.08% of the respondents had knowledge of nuclear electricity generation implying that majority of them had information about the energy source. Approximately 66.67% of the respondents regarded nuclear electricity generation as by and large beneficial despite the risks associated with it. Consequently, they agreed with its inclusion in the country's energy mix.

The timing of commencement of nuclear electricity generation in the country was classified into three categories. Majority of the respondents (46.88%) were of the opinion that Kenya should begin to generate nuclear electricity in later years. The rest of the respondents were either of the view that the generation should begin immediately (32.29%) or the country should never generate nuclear electricity (20.83%).

The study further revealed a number of actions that the Government should take in order to address negative perceptions regarding nuclear electricity generation. The respondents were of the opinion that the Government should raise public awareness about use of the technology for electricity generation (63.54%) and carry out other initiatives including formal training (26.04%). There were also respondents who had no opinion regarding what action(s) the Government should take to deal with negative perceptions (10.42%) implying that in their view, the negative perceptions cannot be changed.

Table 4.1 summarizes the statistics that were considered in this study.

Table 4.1. Summary statistics.

Variable	**Mean**	**Std. Dev.**	**Min**	**Max**
Public perception	0.7083	0.4569	0	1
Age	1.6146	0.8255	0	3
18 to 23 years	0.5104	0.5025	0	1
24 to 39 years	0.2708	0.4467	0	1
40 to 59 years	0.1875	0.3924	0	1
Above 60 years	0.0313	0.1749	0	1
Gender (male=1)	0.5417	0.5009	0	1
Knowledge	0.7708	0.4225	0	1
Benefits	0.6667	0.4739	0	1
Remedies	1.1563	0.5863	0	2
Do nothing	0.1042	0.3071	0	1
Public awareness creation	0.6354	0.4838	0	1
Government initiatives and training	0.2604	0.4412	0	1
Timing	1.2604	0.7847	0	2
No opinion	0.2083	0.4082	0	1
Immediately	0.3229	0.4700	0	1
Later years	0.4688	0.5016	0	1

Total number of observations	96

Source: Research data, 2017.

4.2. Correlation Analysis

Prior to estimation, the levels and nature of correlations among variables was analyzed. This is because presence of multicollinearity makes regression coefficients indeterminate thus rendering standard errors infinite. Although multicollinearity is common among variables, what matters is the degree of association. The correlation analysis found that most pairs of relationships were positively related with the exception of correlations between perception and age, age and timing, gender and benefits as well as gender and remedies as shown in table 4.2. It was found that all correlation coefficients, except one, were less than 0.6 in absolute value implying that pairs of variables were not highly correlated. The strength of the association among the variables was explored with strongly and weakly correlated variables being measured by the coefficients close to the absolute values of one and zero respectively.

Table 4.2. Correlation matrix.

Variable	**Public perception**	**Age**	**Gender**	**Knowledge**	**Benefits**	**Remedies**	**Timing**
Public perception	1.0000						
Age	-0.1058	1.0000					
Gender	0.0077	0.0774	1.0000				
Knowledge	0.3590	0.2873	0.1451	1.0000			
Benefits	0.8103*	0.0179	-0.0296	0.2979	1.0000		
Remedies	0.3291	0.2127	-0.0045	0.3585	0.2652	1.0000	
Timing	0.5664	-0.0059	0.0658	0.3407	0.3491	0.2767	1.0000

*Figure represents high correlation

An initial estimation that included the benefits variable that was highly collinear with the public perception variable ran endless iterations with no results being obtained. In order to solve the high correlation problem and therefore proceed with estimation, the benefits variable in the correlated pair was dropped.

4.3. Estimation Results

In order to gain insight into the determinants of public perception in Nairobi County towards nuclear electricity generation in the country, it was important to check the fitness of the selected factors (variables) that were associated with public perception. A logit regression was conducted to estimate the effect of these variables on public perception (acceptance) and the results are illustrated in table 4.3. It should be noted that the logit regression coefficients in the table are interpreted as changes in the logit index.

Table 4.3. Logit regression results.

Public Perception	**Coefficient**	**Std. Err.**	**t**	**P>t**	**95% Conf. Interval**	
Age (Above 60 Years – Base Category)						
18-23 Years	-.8298	1.1376	-0.73	0.466	-3.0594	1.3999
24-39 Years	-2.4814	1.2936	-1.92	0.055	-5.0169	0.0540
40-59 Years	-2.6667	1.2714	-2.10	0.036	-5.1586	-0.1748
Gender	-.1643	0.6887	-0.24	0.811	-1.5141	1.1856
Knowledge	2.0154	0.8376	2.41	0.016	0.3737	3.6571
Remedies (Do Nothing – Base Category)						
Public Awareness Creation	3.8340	1.7092	2.24	0.025	0.4841	7.1840
Government Initiatives and Training	3.8089	1.9389	1.96	0.049	0.0087	7.6090
Timing	1.7233	0.4912	3.51	0.000	0.7605	2.6862
Constant	-4.2494	1.40164	-3.03	0.002	-6.9965	-1.5022

Logistic Regression (Robust)
Number of Observations = 96
Wald chi^2 (8) = 24.75
Prob > chi^2 = 0.0017
Log Pseudo-Likelihood = 32.7815
Pseudo R^2 = 0.4343

Source: Research data, 2017.

The study found that approximately 43.43% of the public's perception toward nuclear electricity (dependent variable) was explained by the independent variables included in the model on the basis of the pseudo-R^2. The remaining proportion can be explained by other factors not taken into consideration in the model and are consequently accounted for by the error term as the model used is a stochastic one. The log pseudo-likelihood was found to be relatively high with an overall p-value of 0.0017, implying that the included variables fitted the model significantly.

The results of the regression showed that the age categories of 24 to 39 years and 40 to 59 years were statistically significant compared to the age category of above 60 years. Knowledge of nuclear electricity generation was also found to be statistically significant. The results also showed that public awareness creation as well as government initiatives and training were statistically significant compared to doing nothing to address negative perceptions regarding nuclear electricity generation. Timing was also found to be statistically significant. Gender, on the other hand, was found to be statistically insignificant. The marginal effects of the variables that were found to be statistically significant are presented in table 4.4. The results form the basis for interpretation and discussion of the statistically significant factors that influence the public's perception in Nairobi County towards nuclear electricity generation in the country.

Table 4.4. Marginal effects of the robust logit model.

Public Perception	**Coefficient**	**Std. Err.**	**t**	**P>t**	**95% Conf. Interval**	
Age (Above 60 Years – Base Category)						
18-23 Years	-0.0561	0.0701	-0.80	0.424	-0.1935	0.0813
24-39 Years	-0.2298*	0.0999	-2.30	0.021	-0.4255	-0.0340
40-59 Years	-0.2546*	0.0857	-2.97	0.003	-0.4226	-0.0867
Gender	-0.0173	0.0721	-0.24	0.811	-0.1586	0.1241
Knowledge	0.2116*	0.0884	2.39	0.017	0.0384	0.3849
Remedies (Do Nothing – Base Category)						
Public Awareness Creation	0.5538*	0.1941	2.85	0.004	0.1734	0.9342
Government Initiatives and Training	0.5509*	0.2103	2.62	0.009	0.1388	0.9631
Timing	0.1810*	0.0324	5.58	0.000	0.1174	0.2445

*Significant at 95% confidence interval

4.4. Interpretation and Discussion of Study Results

The regression results showed that, compared to the older generation in the age category of above 60 years, the younger generation in the age categories of 24 to 39 years and 40 to 59 years has a lower likelihood of accepting nuclear electricity generation in Kenya at 5% level of significance by 22.98% and 25.46% respectively holding other factors constant. This result is consistent with the tendency among older people to be more supportive of nuclear electricity than younger people as put forward in the reviewed literature.

The results of the study also showed that knowledge of how nuclear electricity is generated increases the probability of accepting nuclear technology in the country at 5% level of significance by 21.6% holding other factors constant. This result corresponds with the appriori expectation of a positive relationship between an individual's level of knowledge about nuclear electricity and their perception toward the energy source. It is expected that as individuals obtain information pertaining to nuclear electricity, they are more likely to accept it.

The results indicated that the actions proposed by the respondents to be taken by the Government in order to address negative perceptions regarding nuclear electricity generation were positively related to the public's perception toward nuclear electricity. This relationship suggests that, holding other factors constant, the probability of accepting nuclear electricity can be increased by public awareness creation (55.38%) as well as government initiatives and training (55.09%). This result conforms to the expectation arising from literature with respect to public communication and information as well as involvement of different stakeholders in a country's nuclear electricity programme so as to gain their acceptance of the programme.

The study results pointed to an increase in the probability of accepting nuclear electricity generation in the country by 18.1% with deferred introduction of the electricity to later years at 5% level of significance holding other factors constant. This result implies cognizance of the need for preparatory work to be undertaken prior to introduction of nuclear electricity in a country's energy mix.

CHAPTER FIVE

5. SUMMARY, CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1. Summary

The aspiration in the country's development blueprint to revamp the economy through industrialization is projected to lead to significant increases in electricity demand, in addition to normal growth, increased rural and urban connections as well as the continuing establishment and operationalization of county governments. In order to meet the anticipated demand, nuclear electricity has been taken into consideration as potential source of electricity generation in the long-term. Nuclear electricity is considered to be potentially viable for Kenya because it can help the country achieve energy security, diversify energy sources and maintain long-term stability of electricity prices. This study was hence carried out with the main objective of determining the public's perception in Nairobi County towards nuclear electricity generation in the country. Specifically, the study sought to assess whether or not the public in the capital city of Nairobi would accept nuclear electricity generation in the country. It also sought to investigate the different factors that would shape the accepting and rejecting populations' decisions. The study further sought to draw policy on nuclear electricity generation in the country arising from this study.

The study used primary data collected from 96 respondents who were randomly sampled from the target population which was the people in Nairobi County. The data was collected using a questionnaire that was designed to collect information on the respondents' perceptions of nuclear electricity and the factors that tend to influence their perceptions as identified in this study. The identified factors were age, knowledge about nuclear electricity, remedies and timing (independent variables). A logistic regression model was used to estimate the relationship between the public's perception toward nuclear electricity (dependent variable) and the independent variables.

5.2. Conclusions

The study specifically sought to assess whether or not the public in the capital city of Nairobi would accept nuclear electricity generation in the country. The results of the study showed that 70.83% of the respondents accepted the introduction of nuclear electricity generation in the country while 29.17% rejected it. This implies that majority of the people in Nairobi support the use of nuclear technology to generate electricity in the country.

The study also sought to investigate the different factors that would shape the accepting and rejecting populations' decisions. The factors considered were age, knowledge about nuclear electricity, remedies and timing. The results of the study showed that the younger generation in the age categories of 24 to 39 years and 40 to 59 years had a relatively lower likelihood of accepting nuclear electricity generation in the country compared to the older generation in the age category of above 60 years. The results also showed that knowledge of how nuclear electricity is generated increased the probability of accepting nuclear electricity generation in the country. The results further showed that Government actions taken to address negative perceptions regarding nuclear electricity generation relatively increased the probability of acceptance compared to taking no action. The results also showed that the probability of accepting nuclear electricity generation increased with deferred introduction of the electricity to later years. This suggests that these factors play a role in shaping the public's perception and therefore ought to be factored in during design and implementation of initiatives aimed at gaining acceptance of the technology.

5.3. Policy Recommendations

Public acceptance, among other things, is necessary for successful introduction of nuclear electricity in the country. The results of this study indicate that there is a positive relationship between the public's perception toward nuclear electricity and socio-demographic factors (age), socio-psychological factors (knowledge about nuclear electricity), remedies as well as timing. The Government ought to therefore take cognizance of these factors in designing and implementing stakeholder involvement initiatives that seek to gain public acceptance of the programme. The initiatives ought to be tailored towards creating awareness through adequate knowledge dissemination to the public, particularly among the younger generation. The Government ought to also create public forums through which it can engage different stakeholders in the nuclear electricity programme and get their views so as to ensure sustainability of policy decisions regarding the programme.

5.4. Areas for Further Research

This study sought to determine public perception in Nairobi County towards nuclear electricity generation in the country. The focus on Nairobi County brings about a generalizability problem because the results of the study may not be applicable to the other counties within the country. It is therefore recommended that future studies expand the scope of this study to cover the entire country so as to determine the public perception nationally and the factors that shape that perception (acceptance or rejection). Such studies will permit countrywide generalization and allow for comparison of their findings with those of this study.

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APPENDIX

I. STUDY QUESTIONNAIRE

PERCEPTIONS IN NAIROBI COUNTY TOWARDS NUCLEAR ELECTRICITY GENERATION IN KENYA

Nuclear electricity has been taken into consideration in the country's energy planning as a potential source of electricity to meet the country's demand in the long-term. Nuclear technology used for electricity generation is capable of safely producing large amounts of reliable electricity at relatively low prices. Public acceptance is one of the prerequisites for successful introduction of nuclear electricity in the country.

This questionnaire seeks to anonymously collect information pertaining to your acceptance/rejection of and perception toward the use of nuclear technology to generate electricity. The information you provide will be treated in strict confidence and will be used only for research purposes. Your participation in this study will assist in developing appropriate policies for our country on the subject of nuclear electricity generation.

Kindly take a few minutes to answer to the following questions.

1. What is your gender?

   (a) Male　　(b) Female

2. Where do you reside in Nairobi County?

   (a) Nairobi West　　(b) Nairobi East　　(c) Nairobi North　　(d) Westlands

3. What is your age?

   (a) Between 18 and 23 years　　(b) Between 24 and 39 years

   (c) Between 40 and 59 years　　(d) Above 60 years

4. What is the highest level of education you have attained?

(a) Uneducated (b) Primary certificate

(c) Secondary certificate (d) Bachelor's degree

(e) Master's degree (f) Doctorate degree

Other (please specify): ______________________________

5. Have you ever heard of how nuclear electricity is generated?

(a) Yes (b) No

6. If yes, which is your main source of information?

(a) Formal education (b) Media (c) The internet (d) Nuclear energy forums

Other (please specify): ______________________________

7. In your assessment, which is higher between benefits and risks of nuclear electricity generation?

(a) Benefits (b) Risks

8. Should Kenya introduce nuclear electricity in its energy mix?

(a) Yes (b) No

9. In your opinion, when should Kenya begin to generate nuclear electricity?

(a) Immediately (b) Later years (c) Never

10. In your opinion, what should the Government do to address negative perceptions regarding nuclear electricity generation?

Thank you for your time and responses.