THE ASSESSMENT OF NUCLEAR ENERGY AS A SOURCE OF ELECTRICITY GENERATION IN KENYA: LEGAL AND INSTITUTIONAL PERSPECTIVES

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Thesis submitted to the University of Nairobi, in partial fulfillment of the requirements for the award of the degree of Master of Arts in Environmental Law.

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October, 2021.

DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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12/11/2021

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Declaration by supervisors

This thesis has been submitted with our approval as University Supervisors.

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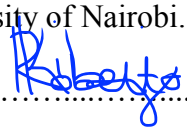

12 Nov 2021

Signature Date

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12 November 2021

Signature Date

Disclaimer

This document describes work undertaken as part of a programme of study at the Centre for Advanced Studies in Environmental Law and Policy (CASELAP), University of Nairobi. All views and opinions expressed therein remain the sole responsibility of the author, and do not necessarily represent those of CASELAP, or University of Nairobi.

ABSTRACT

Electricity is vital for economic development. Sessional paper no. 10 of 2012 on Kenya Vision 2030 seeks, *inter alia*, to accelerate economic growth and increase productivity in all sectors. Consequently, the country will require more electricity to realize the vision to meet the increase in energy demand from growth in industrial and domestic needs. The government is in the process of including nuclear energy in its electricity mix owed to the energy security it is capable of providing. Despite the move towards nuclear energy, the existing legal and institutional framework does not address some of the challenges with nuclear power generation, such as nuclear power plant safety and non-proliferation of nuclear weapons. Therefore, the study analyses the role of nuclear electricity in the emergence of clean energy to increase grid electricity to provide energy security and the need to have changes in the legislative and institutional framework governing nuclear electricity. Respondents from key government state departments and agencies, including Nuclear Power and Energy Agency, Ministry of Energy, Ministry of Environment and Forestry, National Environment Management Authority, Energy and Petroleum Regulatory Authority, Kenya Power and Lighting Company, KETRACO, Rural Electrification, and Renewable Energy Corporation, County Assembly of Mombasa and the National Council for Occupational Safety and Health were interviewed across the energy and environment sectors using semi-structured questionnaires. The methodology used included gathering primary and secondary data like books, publications, journals, and speeches. This study found that the existing legal framework may require review to address the challenges of the role of nuclear electricity to fulfil energy security, the regulatory requirements for siting a Nuclear Power Plant, environmental consequences and public perception and participation. Its recommendations highlighted the need to develop nuclear management institutions like the Nuclear Safety Authority, Nuclear Radio-protection Authority, Nuclear Radiological and Waste Authority, and even regulations for siting.

DEDICATION

This work is dedicated to my mother Jael Mududa who has continuously encouraged me to complete this thesis.

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I extend my sincere thanks to my supervisors, Dr. Robert Kibugi and Prof. Stephen Anyango, for their invaluable comments, constructive criticism, and guidance which enabled me to undertake and complete this work. I am also grateful to Prof. Collins Odote for the monthly meetings and phone calls that kept me on my toes to ensure that the thesis is corrected on time and Dr. Kariuki Muigua, who supervised the corrections. I am equally indebted to the University of Nairobi for the opportunity to undertake these studies at the institution.

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Above all, I give glory to the Almighty God for guiding me throughput out the process.

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ABBREVIATIONS & ACRONYMS

AEC - United States Atomic Energy Commission is commonly known as AEC

CO2 - Carbon Dioxide

EMCA - Environmental Management and Co-ordination Act

EPZ - Emergency Planning Zone

ERB - Electricity Regulatory Board

ERC - Energy Regulatory Commission

FEMA - Federation Emergency Management Agency

GW - Gigawatts

IAEA - International Atomic Energy Agency

IEA - International Energy Agency

ICRP - International Commission on Radiological Protection

ILF - International Legal Framework

ILO - International Labour Office

IRENA - International Renewable Energy Agency

KETRACO - Kenya Electricity Transmission Company

KNBS - Kenya National Bureau of Statistics

KNEB - Kenya Nuclear Electricity Board

KNRA - Kenya Nuclear Regulatory Authority

KPLC - Kenya Power and Lightening Company

LCPDP - Low Cost Power Development Plan

MTP - Medium Term Plan

MW - Mega Watts

NPP - Nuclear Power Plant

NRC - Nuclear Regulatory Commission

NuPEA - Nuclear Power and Energy Agency

REREC - Rural Electrification and Renewable Energy Corporation

SESA - Strategic Environmental and Social Assessment

SSA - Sub Saharan Africa

UNDP - United Nations Development Programme

UNSCEAR - United Nations Committee on the Effects of Atomic Radiation

USA - United States of America

WHO - World Health Organization

CHAPTER ONE: INTRODUCTION

1.1 Background to the study

Energy is an essential commodity that enables socio-economic development[1] from household and community to national and regional. Electricity ought to be affordable and available at all times to cater to the energy demands of households, businesses, and healthcare institutions.[2] Every sector of the economy depends on energy, transport, producing and manufacturing industries, housing, healthcare, and sports sectors[3] all require energy to meet the demands of the modern lifestyle.

1.1.1 The need for energy security

A vast majority of people residing in Sub-Saharan Africa (SSA) do not have access to electricity. This figure translates to 60%, which exceeds a figure of 609 million people.[4] As at 2000, just about 26% of the population had access to electricity, with a marginal rise to 37% in 2014.[5] It is projected that it will take another twenty to thirty years for rural communities in SSA to be connected to the grid.[6] Rural electricity has been recognized as a key component in poverty reduction and enhancement of socio-economic development.[7] Thus energy security should be at the forefront of a country's concern in working towards economic growth and development.

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[1] Bergasse Emmanuel, Wojciech Pacynski et al, 'The Relationship Between Energy and Socio-Economic Development in the South and Eastern Mediterranean' (2013) Executive Summary <https://www.medpro-foresight.eu/system/files/MEDPRO%20TR%20No%2027%20WP4b%20Bergasse_2.pdf> accessed 07 October 2020

[2] IAE, UNDP & IRENA, 'Accelerating SDG 7Achievement Policy Briefs in Support of the First SDG 7 Review at the U.N High Level Political Forum Report' (2018) <https://sustainabledevelopment.un.org/content/documents/22877UN_FINAL_ONLINE_20190523.pdf> accessed 07 October 2020

[3]Emily Cox, 'Securing Energy Sustainability' (2016) <https://www.climate2020.org.uk/securing-energy-sustainably/> accessed 07 October 2020

[4] World Bank, 'State of Electricity Access' (Vol 2 2017) <http://documents1.worldbank.org/curated/en/364571494517675149/pdf/114841-REVISED-JUNE12-FINAL-SEAR-web-REV-optimized.pdf> accessed 07 October 2020

[5] Ibid

[6] World Bank, 'State of Electricity Access Report' (Vol 2 2017) Full Report 31

[7] Raymond Ochieng, 'The Effects of Rural Electrification on the Growth of Small and Medium Enterprises in Mbita Town*'* (2013) 1

Energy security is defined in terms of efficiency, environmental stewardship, affordability, and availability.[8] According to the World Bank, energy security is defined to include minimization of price volatility, diversification of supply, and energy efficiency.[9] The RIO+20 Sustainable Development Conference highlighted the critical role of energy in sustainable development.[10] To enhance sustainable energy access, one of the RIO+20 outcomes, the Sustainable Electricity For All initiative,[11] aims to double the rate of energy efficiency improvement, double the share of renewable energy in the global energy mix, and provide universal access to modern energy services by 2030.

The three global electricity objectives being pursued include energy access, renewable energy, and energy efficiency.[12] Access to modern forms of energy should be available for the world's poorest,[13] as well as adequate electricity supply for modern infrastructure and the necessary high energy-consuming industries. The share of renewable energy, such as wind power, solar power, hydropower, biomass (modern and traditional), and geothermal power, in final energy available to actual users, should be increased from 15% to 30% by 2030. This would lead to the realization of an impressive leap of the Global energy intensity, an improvement averaging 2.4% annually as between 2010 and 2030, considering that the historical rate stands at half the projected rate.

<http://erepository.uonbi.ac.ke/bitstream/handle/11295/61664/Ouma_The%20effects%20of%20rural%20electrification.pdf?sequence=3&isAllowed=y >accessed 07 October 2020

[8] Benjamin Sovacool and Marilyn A. Brown 'Competing Dimensions of Energy Security: An International Perspective' (Annual Review of Environment and Resources Vol. 35 2010) 77-108 <http://www.annualreviews.org/doi/pdf/10.1146/annurev-environ-042509-143035 accessed 28 July 2014

[9] Ibid

[10] Joeri Rogelj et al. 'The U.N's Sustainable Energy for All Initiative is Compatible to with a warming limit by 2 degrees' (2013 <http://www.nature.com/nclimate/journal/v3/n6/pdf/nclimate1806.pdf> accessed 20 July 2014

[11]Kraft, J and Kraft, A., 'Relationship between energy and GNP' Journal of Energy and Development (vol .3 1978) 401-403

[12]Joeri Rogelj et al., 'The U.N's Sustainable Energy for All Initiative is Compatible to with a warming limit by 2 degrees' (2013) <http://www.nature.com/nclimate/journal/v3/n6/pdf/nclimate1806.pdf > accessed 20 July 2014

[13] Framework for Action 23-2012

Whenever energy efficiency is achieved, energy demands will go down in the economy. The public plays a critical role in these developments, as in addition to the technological and economic challenges, their acceptance of the technologies and associated risks is a major contribution.[14]

1.2 Energy Analysis in Kenya

The government put in place a strategy transforming current energy infrastructure into a more advanced infrastructure network based on modern practices, seeking to avail energy at affordable prices and on a reliable basis to homes and businesses.[15] The move will result in improved energy utilization among households, manufacturing industries, within the public sector, and agriculture. The move is aimed at advancing installed capacity for electricity generation to 5, 221 MW in 2022[16] , and the installed generation capacity was 2,333 MW in June 2017.[17]Kenya's current installed electricity capacity is estimated at 2.4GW, 1.5 GW of which is grid-connected and 500MW which has come online since mid-2014.[18]The electricity demand for electricity was at 1,656 MW in June 2017.[19] However, there has been a decline in the rates of electricity consumption per user. The primary cause could be the imbalance between electricity generation rates, which is slow, and an ever-increasing demand for electricity. Additionally, it could be due to the limited expansion of the electricity connection network.[20] Stagnating demands threatening the national

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[14]Joeri Rogelj et al. 'The U.N's Sustainable Energy for All Initiative is Compatible to with a warming limit by 2 degrees' (2013) <http://www.nature.com/nclimate/journal/v3/n6/pdf/nclimate1806.pdf> accessed 20 July 2014

[15] Vision 2030 MTP III 2018-2022

[16] Ibid

[17] LCPDP 2017-2037 pg 13

[18]Robert Wilson, 'Renewable Energy Opportunities in Kenya' (2016) 5 <https://www.filepicker.io/api/file/BHdNGfKSBSeJ0h3hezsr> accessed 06 June 2020

[19] LCPDP 2017-2037 pg 16

[20] Institute of Economic Affairs, 'Situational Analysis of Energy Industry, Policy and Strategy for Kenya' (2015) 8 <https://media.africaportal.org/documents/Situational-Analysis-of-Energy-Industry-Policy-and--Strategy-for-Kenya_1.pdf> accessed 20October2020

utility and exaggerated forecasts, which ultimately lead to over-investment in electricity generation, are highlighted as risks to the country's power sector.[21] As consumption growth has stagnated, the government has abandoned a 2013 proposal to add 5000 MW. There is very little likelihood of this happening as the concerned ministry underscored that the growth in demand does not match earlier projections, with a resulting slump in plan implementation.[22] The Vision 2030 medium-term plan seeks to increase energy via renewable energy and other options to ensure energy affordability and reliability. Nuclear energy should be part of the other options, given the base load it can provide compared to other renewable sources of energy. The need for economic growth led to the establishment of the Nuclear Power and Energy Agency and the enactment of the Energy Act, 2019, to fast-track the development of nuclear energy in Kenya.

There is every indication for a hike in energy demand in the future since there is a trend towards urbanization and an increase in homes. Adequate preparations have to be made to ensure that such future demand is matched. Nuclear power is considered clean due to the fact that its GHG emissions are negligible, it is economically competitive and reliable by providing a stable base load needed for socio-economic development.[23]

The major reason for taking into account nuclear power as part of energy sources in Kenya is the need to mitigate climate change.[24] Even though nuclear energy stands out as a viable option towards meeting the projected demand, issues of proliferation of waste management and radiation risks are major concerns. It is also noteworthy that radiation risks associated with nuclear energy are on the low, nearly matching medical or natural radiation whose effects are negligible.

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[21] Rose Mutiso & Jay Taneja, 'The Seven Major Threats to Kenya's Power Sector' (2018) <https://www.energyforgrowth.org/memo/the-seven-major-threats-to-kenyas-power-sector/> accessed 06 November 2020

[22] Macharia Kamau, 'Demand Setback Now Puts Kenya's Mega Power on the Back Burner' (2017)

[23] International Atomic Energy Agency, 'Climate Change and Nuclear Power' (2015) 2

[24] Ibid 4

Nuclear energy generates base-load electricity with no output of carbon[25] , which is needed in this climate change era to lower the rates of release of carbon gases to the atmosphere. Nuclear energy power plants have a greater energy production capacity as compared to fossil fuels and renewable energy.[26] Capacity factors explain the percentage of time a power plant is capable of producing energy, and since renewable energy depends on the rain to fall, the wind to blow, and the sun to shine, it cannot compare to nuclear energy which performs at 93 percent which is reliable thus provides energy security. Radiation levels released by nuclear power are lower than any other source of energy. During burning, coal produces fly ash which is responsible for major radioactive releases to the environment.

Kenya's Vision 2030 MTP III 2018-2022 seeks to update the load forecast taking into account the enabling factors contributors like the legislative framework, site identification, international partnerships, and public education. The challenges experienced include low supply, low investments rates by the private sector, poor transmission, affordability concerns, lack of major investments in the sector by the private sector, weak transmission, frequent power outages, low voltages, low connectivity rate and vandalism.[27] For instance, the cost of power is 21 US cents per Kwh, a figure on the higher end than the 6 US cents per kWh in China and India,[28] affected growth and development in the country as energy use cuts across all sectors of the economy. Kenya's sources of electricity generation mix comprise 39% from hydropower, 12 % from oil, 46%

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[25] Richard Rhodes, 'Why Nuclear Power Must Be Part of the Energy Solution' (2018 <https://docs.google.com/document/d/1HHVtsWPKgKpDBxcwBpmiFNQdb3YDlK4ewdUF0kD4ZuE/edit?ts=5ee14f7e#> accessed 12 July 2020

[26] Ibid

[27] Institute of Economic Affairs 2013

[28] Vision 2030 *Medium Term Plan II* 2013-2017 (3)

geothermal energy, 1.2% biogas cogeneration, and wind power at 0.4%, respectively. [29] It has utilized just 30% of hydropower, 4% of geothermal resources, with low levels of wind or solar power use.[30] Hydropower provides more than 39% of electricity production in Kenya, making it difficult during summer since the water levels are low.[31]

Petroleum is associated with the generation of greenhouse gases, air pollution in general, and the high cost of electricity due to unstable global crude oil pricing. Events such as hurricanes, massive oil leaks, terrorism attacks disrupt the flow of both crude oil and finished products. Since supply and demand are relatively inelastic, any mentioned events can lead to higher price volatility, especially in future markets.[32]This therefore means that prices are controlled by market forces including events mentioned above and supplies. When the supply volume goes up the price of oil drops thus the volatility.

The Minister for energy according to regulation 11 of the Energy (Petroleum Pricing) Regulations, 2010, has the power to review fuel prices according to the formula specified in regulation 4.[33] In 2019, the cost of electricity was USD 0.150 per kWh but it is projected that when nuclear electricity is installed into the grid the price of electricity would drop about three times the current market rates.[34]Electricity pricing is usually affected by fuel prices that have been very volatile. A litre of

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[29] Final Energy Report of Kenya *IEA Statistics* 2015 - 2018 <https://www.rvo.nl/sites/default/files/2019/01/Final-Energy-report-Kenya.pdf> accessed 01 June 2020

[30] Jeremy K. Kiplagat et al., 'Renewable Energy in Kenya: Resource Potential and status of exploitation' (2011) <http://www.sciencedirect.com/science/article/pii/S1364032111001262> accessed 20 July 2014

[31] Kees Mokveld & Steven Von Eij, 'Final Energy Report Kenya' <https://www.rvo.nl/sites/default/files/2019/01/Final-Energy-report-Kenya.pdf> accessed 01 June 2020

[32]David Fessler, 'What Really Drives Crude Oil Prices' (2011) <http://www.investmentu.com/article/detail/23335/what-drives-crude-oil-prices#.UyWQEkHfrMw> accessed 15 March 2014

[33] Legal Notice No. 196 of 2010

[34] Erick Maklago 'Cost of power will go down threefold if we adopt nuclear energy' (2019) <https://www.standardmedia.co.ke/article/2001333225/cost-of-power-will-go-down-threefold-if-we-adopt-nuclear-energy> accessed 09 July 2020

super petrol was Kshs.90.40 in April 2020 in Nairobi and Kshs.105.43 in October 2020, which increased by 1.12 and was effected from 3rd October 2020 due to an increase in excise duty.[35] Electricity tariffs are also erratic and, more often than not, increase. For example, the 2020 electricity tariff stipulated that Kenyans pay Kshs.12.00 instead of 2.5 for 0 to 10 kw. Note - for 40 units, payment of 15.80 per unit is Kshs 13.30 more per unit than what you used to pay in 2019.[36] However, the price regulation negatively impacted the profitability of oil marketing companies.[37] Overall, high oil prices have a resultant effect of reduced overall economic growth because of higher inflation, lower corporate profits, and higher unemployment rates.[38] The fuel cost charge in the electricity bills depends on fluctuations in world prices as well as fluctuations in the quantity of oil consumed by electricity generation.

Geothermal energy has its own challenges. The determination of resources depends on the geological system thus requiring exploration drilling to confirm the resource potential, high project costs needed to mobilize resources, and high project risks, which require partial risk guarantees.[39] This means that financial resources have to be utilized even before the production electricity. Further, heavy funding is needed to run the project and facilitate risk guarantees. It shows how expensive geothermal is, making it unattractive for large-scale private investors to explore.

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[35] Legal Notice no. 194 of 2020

[36] New KPLC tariffs and electricity charges in 2020 <https://www.tuko.co.ke/281712-new-kplc-tariffs-electricity-charges.html accessed 11October2020>

[37] Teresa Njogu 'The Impact of Oil Price Regulation on the Profitability of Oil Marketing Companies in Kenya' <http://chss.uonbi.ac.ke/sites/default/files/chss/TERESA%20NJERI%20WANJOGU%20FINAL%20PROJECT.pdf > accessed 27 July 2014

[38] Johnson Munyua and Mary Ragui, 'Drivers of Instability in Prices of Petroleum Products in Kenya' (2013) <http://primejournal.org/BAM/pdf/2013/mar/Munyua%20and%20Ragui.pdf> accessed 28 July 2014

[39] Godwin Mwawongo, 'Geothermal Energy Challenges and Opportunities in East Africa' (2015)

The Lake Turkana Wind Power Project experienced challenges in land access for both site selection and transmission connection.[40] It also experienced project implementation delays, and some stakeholders are dissatisfied with its interactions with the affected communities.[41] The land was leased with minimal consultation from the locals, and there is a case in court alleging that the land was leased illegally.[42]

Fluctuating wind and solar energy require lots of energy storage and lithium-ion batteries are the most readily available choice but are far too expensive to play a major role.[43]

Nuclear energy has been identified as one of the energy sources that would substantially address the prevailing energy deficit.[44]Nuclear power currently provides about 13% of electrical power worldwide and has emerged as a reliable base load source of electricity.[45] It is the most environmentally benign way of producing electricity on a large scale in efficiency and cost. The quantities needed are much less than for coal or oil.[46] Nuclear power is the only technology used to produce electricity that, from the onset of its development takes environmental impact into consideration and research and research on safety was developed with technology.[47] The radioactive waste produced from a nuclear power plant causes less radiation to the population than

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[40] Kees Mokveld & Steven Von Eij 'Final Energy Report Kenya' (2018) 7 <https://www.rvo.nl/sites/default/files/2019/01/Final-Energy-report-Kenya.pdf> accessed 01 June 2020

[41] Hannna Akuiyibo, 'Public Private Partnerships in Africa: Some Lessons from Kenya's Lake Turkana Wind Power Project' (2019) <https://africaupclose.wilsoncenter.org/public-private-partnerships-in-africa-some-lessons-from-kenyas-lake-turkana-wind-power-project/> accessed 02 June 2020

[42] Zoe Cormack 'Kenya's huge wind power project might be great for environment but not for local communities' (2019) available <https://qz.com/africa/1700925/kenyas-huge-wind-power-project-in-turkana-hurts-local-people/> accessed 14 June 2020

[43] James Temple, 'The USD 2.5 Trillion Reason We Can't Rely on Batteries to Clean up the Grid' (2018) <https://www.technologyreview.com/2018July27/141282/the-25-trillion-reason-we-cant-rely-on-batteries-to-clean-up-the-grid/> accessed 09July2020

[44]Juma, C. G Presentation to The Dialogue Forum on 'Long term prospects for nuclear energy in the post-Fukushima era' (2012) 16 <http://www.iaea.org/INPRO/5th_Dialogue_Forum/DF5-Proceedings.pdf> accessed 03 February 2014

[45]Zinkle and Was 'Material Challenges in Nuclear Energy' (2013) <http://www.sciencedirect.com/science/article/pii/S1359645412007987> accessed 28 July 2014

[46]*Supra* note 48

[47] Margarit Pavelescu, Alexandra Pavelescu et al., 'Nuclear Power and the Environment' (2004) 480 <http://www.nipne.ro/rjp/2005_50_5-6/0473_0492.pdf> accessed 08 July 2020

that produced by radon, chest x-ray, or dental x-ray.[48] Nuclear energy is a fast-growing energy choice for countries seeking energy security and low emission energy solutions to reduce CO_2 emissions and mitigate global climate change.[49] Even though some countries are moving away from it and decommissioning, the data shows that about thirty countries are considering, planning, or starting nuclear power programmes, and further twenty or so countries have at some point expressed an interest.[50] It is a proven, large-scale source of electrical production at rates competitive with today's CO_2-emitting, fossil-fueled technologies.[51] Fossil fuels are polluting, and carbon dioxide emissions from their combustion are responsible for global warming. [52]

1.3 Environmental risks of nuclear power

Whereas nuclear power is associated with numerous positive aspects, some negative aspects have to be addressed.[53]These challenges must be successfully resolved for nuclear energy to continue improving reliability, safety, and economics.[54]Concerns revolve around the storage of radioactive wastes, security measures to ensure that nuclear materials are not acquired by terrorists, proliferation of nuclear weapons, and catastrophic nuclear accidents.[55]

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[48] Margarit Pavelescu, Alexandra Pavelescu et al., 'Nuclear Power and the Environment' (2004) 480 <http://www.nipne.ro/rjp/2005_50_5-6/0473_0492.pdf> accessed 08 July 2020

[49] ANSTO 'Nuclear Energy' <http://www.ansto.gov.au/NuclearFacts/BenefitsofNuclearScience/NuclearEnergy/> accessed 28 July 2014

[50] World Nuclear Association 'Emerging Nuclear Energy Countries' (2020) <https://www.world-nuclear.org/information-library/country-profiles/others/emerging-nuclear-energy-countries.aspx> accessed 07 July 20

[51] Miller and Romney Duffey, *'Sustainable and Economic hydrogen cogeneration from nuclear energy in competitive power markets' (*2005) <http://www.sciencedirect.com/science/article/pii/S0360544204003159> accessed 28 July 2014

[52] Brown et al., 'High Efficiency Generation of Hydrogen Fuels Using Nuclear Power' (2003) <https://fusion.gat.com/pubs-ext/AnnSemiannETC/A24285.pdf> accessed 28 July 2014

[53] OECD/IAEA-NEA, 'Projected costs of Generating Electricity' (2010) <https://www.oecd-nea.org/ndd/pubs/2010/6819-projected-costs.pdf> accessed 27 July 2014

[54]*Supra* note 49

Nuclear energy poses a risk to the environment and the community because of leakage of pollutants into water, damaging aquatic life and the water quality. Waste can also be generated from uranium mining operations and the traces of radioactive uranium go into the rainwater runoff, contaminating the groundwater and the surfaces.[56] This problem means that human beings and aquatic life are at risk due to exposure to contaminated water. The community can suffer from health effects of radiation which damage biological cells and thereby initiate cancer.[57]However, environmental harmonization of nuclear energy technology is considered necessary in its future successful development for peaceful use.[58] Countries like Japan have put safety measures in place to ensure safety during unusual events that can be summarized into:

i. to shut down operating reactors

ii. to cool down reactors to remove heat from nuclear fuel and

iii. to contain radioactive material.[59]

Nuclear power plant safety includes an emergency core cooling system. When an accident occurs, huge amounts of water will be automatically poured into a nuclear reactor to cool down nuclear fuel. There are systems that prevent accidents from spreading, so when disruptions occur, it prevents the emission of radioactive material.[60] There is also environmental radiation monitoring which includes measuring radiation dose in the air by radiation monitoring systems around the

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[56]Environmental Protection Agency, 'Nuclear Energy' <www.epa.gov/cleaning /energy-and-you/affect/nuclear.html> accessed 09 July 2014

[57]Benard L Cohen, 'Risks of Nuclear Power' <www.umich.edu/-radinfo/introductio/np-risk.htm> accessed 09 July 2014

[58] Masaki Saito, 'Multi-Component Self Consistent Nuclear Energy Systems for Sustainable Growth' (2002 <http://www.sciencedirect.com/science/article/pii/S0149197002000306> accessed 28 July 2014

[59] The Federation of Electric Power Companies of Japan, 'Safety Measures at Nuclear Power Plants' <https://www.fepc.or.jp/english/nuclear/power_generation/safety_measures/index.html> accessed 07 July 2020

[60] The Federation of Electric Power Companies of Japan, 'Safety Measures at Nuclear Power Plants' <https://www.fepc.or.jp/english/nuclear/power_generation/safety_measures/index.html> accessed 07 July 2020

plants, periodic collection of seawater, soil and agricultural, as well as sea products to measure and analyse them for radioactive material to ensure that power plants have no adverse impacts to their surroundings.[61]

Currently, there are nuclear reactors that operate online refueling systems. This is a technique that allows nuclear fuel to be removed or added during operation, which means that the reactor does not need to be shut down to be refueled.[62] This has made it easier for countries using these reactors to refuel without having to shut down the plants. Spent fuel pools harbour enormous quantities of radioactive fuel.[63] The only way to prevent nuclear terrorism is to keep terrorists from acquiring nuclear material or finding accessing nuclear facilities.[64]Terrorists with sufficient expertise could in theory build a nuclear bomb but only with serious difficulty since starting a chain reaction is not simple.[65] It is a possibility that terrorists can access nuclear facilities; therefore, any country with nuclear power plants should deal with this through legislation to ensure that it is extremely difficult for terrorists to access.

The safety standards in the nuclear sector worldwide are set by the International Atomic Energy Agency. The general safety principles are amongst them, including governmental, legal, and regulatory frameworks for safety.[66]Safety issues may emerge, and nuclear weapon proliferation is

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[61] *Supra* note 59

[62] Energy Education, 'On-line refuelling of Nuclear Power Plants' (2018) <https://energyeducation.ca/encyclopedia/On-line_refueling_of_nuclear_power_plants> accessed 09 July 2020

[63] Ira Helfand, L. Forrow & J. Tiwari, 'Nuclear Terrorism' (2002) <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC1122278/> accessed 11 October 2020

[64] Kenneth Brill & J.H Berhad, 'Preventing Nuclear Terrorism: Next Steps in Building a Better Nuclear Security*'* This has not been not addressed in the Nuclear Regulatory Act, 2019 civil liability is a very important aspect in nuclear law. (2017) <https://www.armscontrol.org/act/2017-10/features/preventing-nuclear-terrorism-next-steps-building-better-nuclear-security-regime> accessed 11 October 2020

[65] Gwyneth Cravens, 'Terrorism and Nuclear Energy: Understanding the Risks' (2002) <https://www.brookings.edu/articles/terrorism-and-nuclear-energy-understanding-the-risks/> accessed 09 July 2020.

[66] Gustavo Caruso, 'IAEA Safety Standards for Regulatory Activities' (2010) <http://www-ns.iaea.org/downloads/ni/training/safety_standards_presentations/IAEA%20Safety%20Standards%20-%20Regulatory%20Activity.pdf> accessed 28 August 2014

one of the most feared concerns. A connection between nuclear power and nuclear weapons exists because both require fissile materials.[67] Nuclear energy also emits ionizing radiation, which is harmful to people and the environment if maximum limit emissions are not taken into consideration.

Optimization of protection is one of the principles set by IAEA to safeguard radiation effects.[68]Legislation is needed to control the effects of radiation and many other factors, as explained above. The United States of America (U.S.A) has managed challenges related to nuclear plants due to the measures it has put in place discussed below. Security Regulations- Which divides the plant sites into three zones: an "owner-controlled" buffer region, a "protected area," and a "vital area." Access to the protected area is restricted to a portion of plant employees and monitored visitors, with stringent access barriers. The vital area is further restricted, with additional barriers and access requirements.[69]This provides for the protection of nuclear plants from land-based assault.

The Nuclear Regulatory Commission (NRC) requires that within an approximately 10-mile Emergency Planning Zone (EPZ) around each plant, the operator must maintain warning sirens and regularly conduct evacuation exercises monitored by NRC and Federation Emergency Management Agency (FEMA)[70] due to the increased incidents of terrorist attacks worldwide.

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[67] Nuclear Information, '*The Challenges of Nuclear Power'* <http://nuclearinfo.net/Nuclearpower/TheRisksOfNuclearPower> accessed 01 September 2014

[68]International Atomic Energy Agency Safety Standards Series N. SF-1 –Fundamental Safety Principles

[69] Carl Behrens and Mark Halt, 'Nuclear Power Plants: Vulnerability to Terrorist Attack' Washington, DC: Congressional Research Service, 2005) <http://www.fas.org/irp/crs/RS21131.pdf>

[70] Carl Behrens and Mark Halt, 'Nuclear Power Plants: Vulnerability to Terrorist Attack' Washington, DC: Congressional Research Service, 2005) <http://www.fas.org/irp/crs/RS21131.pdf>

Kenya should learn from countries that have used nuclear energy for a long time, like the U.S.A, to have global standards in our legislation. The government is seeking to build capacity and domesticate requisite technologies, initiating exploration activities for nuclear mineral resources and undertaking feasibility studies in the development and safe utilization of nuclear energy for generation of electricity. Nevertheless, legal and institutional frameworks that can deal with challenges posed by nuclear power, such as the storage of radioactive wastes, security measures to ensure nuclear materials are not acquired by terrorists, proliferation of hazardous nuclear wastes, and catastrophic nuclear accidents, are necessary. Lack of such comprehensive regulatory frameworks can prove to be of negative impact to Kenya in nuclear electricity generation. When the Constitution of Kenya was passed in 2010, the governance structure of the Country was changed, making it necessary to review the energy sector framework. It led to the review of the Energy Policy (Sessional Paper No. 4 of 2004) and the repeal of the Energy Act, 2006, thereby ushering in the Energy Act, 2019. The Nuclear Regulatory Act, 2019 establishes the Kenya Nuclear Regulatory Authority, which shall oversee regulatory control, radiation protection, the safety of radiation sources and facilities. This is the Act that provides for nuclear power production from issuance of a license to protection of the people and environment to decommissioning. This, together with other statutes in Kenya, will be used to ensure that nuclear energy does not cause havoc to the people and the environment.

Article 42 of the Kenyan Constitution,2010 protects both the people and the environment as it affords the right to a clean and healthy environment. Article 69 provides for the obligations of the State and the duty of people to ensure that the environment is protected and conserved. The Environmental Management and Coordination Act, 1999 provides various checks and balances to ensure that the environment is protected. This is through Strategic Environmental Assessment, Environmental Impact Assessment, Environmental Audit, Environmental Monitoring, and effluent

discharge permits. NEMA completed the SESA report in March, and some of the environmental risks that were analysed include flooding, nearness to rigorous mining and quavering mining activities that might cause tremors, nearness to aircraft movement with potential aircraft perils.[71] The report also highlights that there is lack of policy governing occupational health and safety in the nuclear sector and that the Occupational Safety and Health Act, 2007 does not cover community health and safety.[72] These are some of the gaps that need to be addressed before NPP is constructed.

The Environmental Management and Co-ordination (Water Quality) Regulations, 2006 provides the standards for effluent discharge into waters; however, radioactive substances are not covered. Nuclear waste is radioactive thus cannot be discharged into the waters. Nonetheless, the cooling water can be discharged into waters since the radioactive water that contacts the nuclear fuel rods is not released to the environment due to the fact that process water operates in a closed loop.[73] The Energy Act, 2019 provides for Nuclear Power in regard to the institution that shall promote nuclear electricity generation. This institution strongly comes out as the fast trackers of nuclear energy by providing a roadmap, while the Nuclear Regulatory Act, 2019 establishes the Kenya Nuclear Regulatory Authority to ensure that nuclear energy in Kenya is safely, securely and peacefully used. This is an umbrella body that will license, review decisions, deal with the radioactive waste management, safety of people and environment, and safety at the nuclear power plant. It, therefore, means that the two institutions will have to collaborate in the drafting of laws.[74]

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[71] NEMA, 'Strategic Environmental and Social Assessment Report for Kenya's Nuclear Power Programme' (2020) 20

[72] Ibid 86

[73] Brandon Clark, '*Thermal Water Pollution from Nuclear Power Plants'* (2019) Stanford <http://large.stanford.edu/courses/2019/ph241/clark1/> accessed 25 July 2020

[74] Energy Act 2019, S. 30

Nuclear accidents in developed countries such as Russia, India, and Japan demonstrate the need for Kenya to take precautions before venturing into nuclear energy exploration. Indeed, Kenya does not have the safety facilities and economic ability like those in developing countries, and thus the importance of thorough research on nuclear energy before this form of energy is introduced.[75] After the disaster that struck the Fukushima Daiichi nuclear plant in Japan, some countries decided to halt nuclear energy generation while others continued. However, UK policymakers were undeterred, and they remained committed to increasing nuclear power generation. In Germany, the federal government was cautious and temporarily shut down the older generation of nuclear reactors and re-examine the safety of all national nuclear power facilities.[76]

The final draft of the National Energy Policy[77]recognizes the generation of electricity using nuclear energy. The draft acknowledges that the uptake of nuclear power technology has grown over time across the world and was gaining acceptability among those countries that did not have while those who had were expanding capacity.

Kenya needs a source of electricity with a massive base-load in order to be able to adequately provide for the country's industrialization needs. Hydro-power, geothermal, wind, and solar energy have so far not been able to provide that base-load. The IAEA provides for the guidelines to be followed when sitting. Kenya is yet to declare any sites that have been identified for nuclear electricity generation, but the siting process has commenced. The guidelines should strictly be adhered to. The Nuclear Regulatory Act, 2019 provides one institution which will deal with all the nuclear issues under one roof. However, nuclear electricity production has various components

[75] National Environmental Policy 2013

[76] Bettina and Wittneben, 'The Impact of Fukushima Nuclear Accident on European Nuclear Policy' (2012) <http://www.sciencedirect .com/science/article/pii/S1462901111001444> accessed 28 July 2014

[77]Government of Kenya (2015). Final draft National Energy and Petroleum Policy

like radioactive waste management that is sensitive and needs a different institution to deal with. The Act also provides that the Authority will authorize persons who carry out nuclear activities. Still, if aggrieved by the decision of the Authority, it shall be reviewed by the authority, which shall be the judge and the jury.

1.4 Statement of the problem

Least Cost Power Development Plan 2017-2037 estimates the demand during the term 2017-2037 will range from 1,754 to 9,790MW in the peak. Kenya is considering nuclear electricity production due to this projected energy demand considering population growth and urbanization, the electricity consumption of commercial and industrial customers, and the flagship projects. Nuclear electricity is associated with providing base-load electricity on a large scale. It does not produce greenhouse gases, and the cost of electricity will be three times cheaper than the current rates. This new plan can work better in conjunction with the hydro-power, solar, geothermal and wind sources mentioned in the Plan, some of which already exist in the national grid.

The most significant deterrent against nuclear power is that it poses environmental risks. It will be problematic in the context of the Constitution of Kenya, 2010, which guarantees the right to a safe and healthy environment. Article 42, Article 10 provides for the participation of the people, human rights, good governance, and sustainable development, while Article 69 protects biodiversity and genetic resources. It also establishes systems of EIA, environmental audit and monitoring of the environment. The Energy Act, 2019 and the Nuclear Regulatory Act, 2019, also govern the nuclear sector. For Kenya to achieve sustainable nuclear electricity production, the Government needs to comply with the IAEA standards. The road-map to nuclear electricity generation has bottlenecks in capacity building and the legal and institutional framework. Nuclear also poses challenges such as storage of radioactive wastes, security measures to ensure terrorists, and catastrophic nuclear

accidents do not acquire nuclear materials. The environmental risks must be mitigated. This thesis examines whether these new laws comply with the principles of national governance, the human right to a clean and healthy environment under the Constitution, and other environmental obligations that govern the nuclear power sector in Kenya.

1.5 Research Questions

The following research questions guided the study:

i. What is the role of nuclear energy in the fulfillment of electricity security for economic growth in Kenya?
ii. What are the requirements for siting a nuclear power plant in Kenya?
iii. What are the gaps in the existing legislative and institutional framework for nuclear electricity generation in Kenya?
iv. What are the laws and institutions needed for nuclear electricity production in Kenya?

1.6 Objectives

The objectives of the study were to:

i. To assess the role of nuclear energy in the fulfillment of electricity security for economic growth in Kenya.
ii. To evaluate the regulatory requirements of nuclear power plant sites in Kenya.
iii. To assess the gaps in the existing legislative and institutional framework for nuclear energy generation in Kenya.
iv. To propose laws and institutions needed for nuclear electricity production in Kenya.

1.7 Justification of the Study

The study will add knowledge on nuclear electricity production and use in Kenya to achieve energy security for economic development. It takes into consideration the risks and challenges involved in the production of nuclear electricity.

The study results also show the dynamics of the generation of nuclear electricity as a clean electricity source and the international standards needed to manage nuclear plants.

1.8 Theoretical Framework of the study

This study can be well explained through the theory of energy security by Benjamin Sovacool, who distinguishes twenty dimensions of energy security which include; innovation, availability, dependency, access reliability, efficiency, decentralization, price stability, affordability, literacy, diversification, governance, greenhouse pollution, resilience and greenhouse emissions[78] It is further explained that this theory is broken into five dimensions which are; technology development, availability, regulation, affordability, and sustainability. Regulation is further broken down into twenty segments touching on price stability, supply, and production security, decentralization, energy efficiency, land use, dependency, access and equity, air pollution for sustainability, water, knowledge for sound regulation, trade, competition, governance, resilience, innovation and research, diversification for affordability, safety and reliability.[79] This approach can be explained as having enough energy sources to be converted to energy services, enhancing accessibility to critical energy services at a considerably low cost and at a fairly stable price.

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[78] Jessica Jewell, 'Energy Security and Climate Change mitigation; The interaction in long term global scenarios' (2013< http://www.etd.ceu.hu/2013/jewell_jessica.pdf> accessed 28 July 2020

[79] Benjamin Sovacool and Mukherjee I., '*Conceptualizing and measuring Energy Security: A Synthesized Approach'* (2011) <file:///C:/Users/CHRISTINE/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/SSRN-id3445378%20(1).pdf> accessed 28 July 2020

Further, ease of adaption and recovery from power supply interruptions is enhanced. Investment into new aspects of research, effective and adequate maintenance for reliability purposes is also assured.[80] It also considers the conservation of forest cover to considerably limit energy loss through degradation of critical natural resources like land, vegetation, water air sheds. Generally, it contributes to conserving the global climatic system. Furthermore, there is a need to have a reliable policy-making mechanism that allows for participation by both the consumers and policymakers.[81] This relates to the research problem that highlights the current electricity mix that is unreliable and expensive but can be improved by the inclusion of nuclear energy that is reliable and affordable, thus creating energy security yet decarbonizes at the same time. The theory takes into consideration the provisions of the Constitution. The production should take into consideration Article 10 of the Constitution of Kenya that provides for the principle of sustainable development, good governance, and participation of the people, Article 42 that provides for the right to a clean and healthy environment provided by the use of nuclear energy which does not emit greenhouse gases and Article 69 which provides for the protection of genetic resources and biodiversity, establishes systems of EIA, environmental audit and monitoring of the environment. These systems have to be adhered to in order to deliver a clean and safe environment.

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[80] Benjamin Sovacool and Mukherjee I., '*Conceptualizing and measuring Energy Security: A Synthesized Approach'* (2011) <file:///C:/Users/CHRISTINE/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/SSRN-id3445378%20(1).pdf> accessed 28 July 2020

[81] *Supra* note 84

1.9 Conceptual Framework

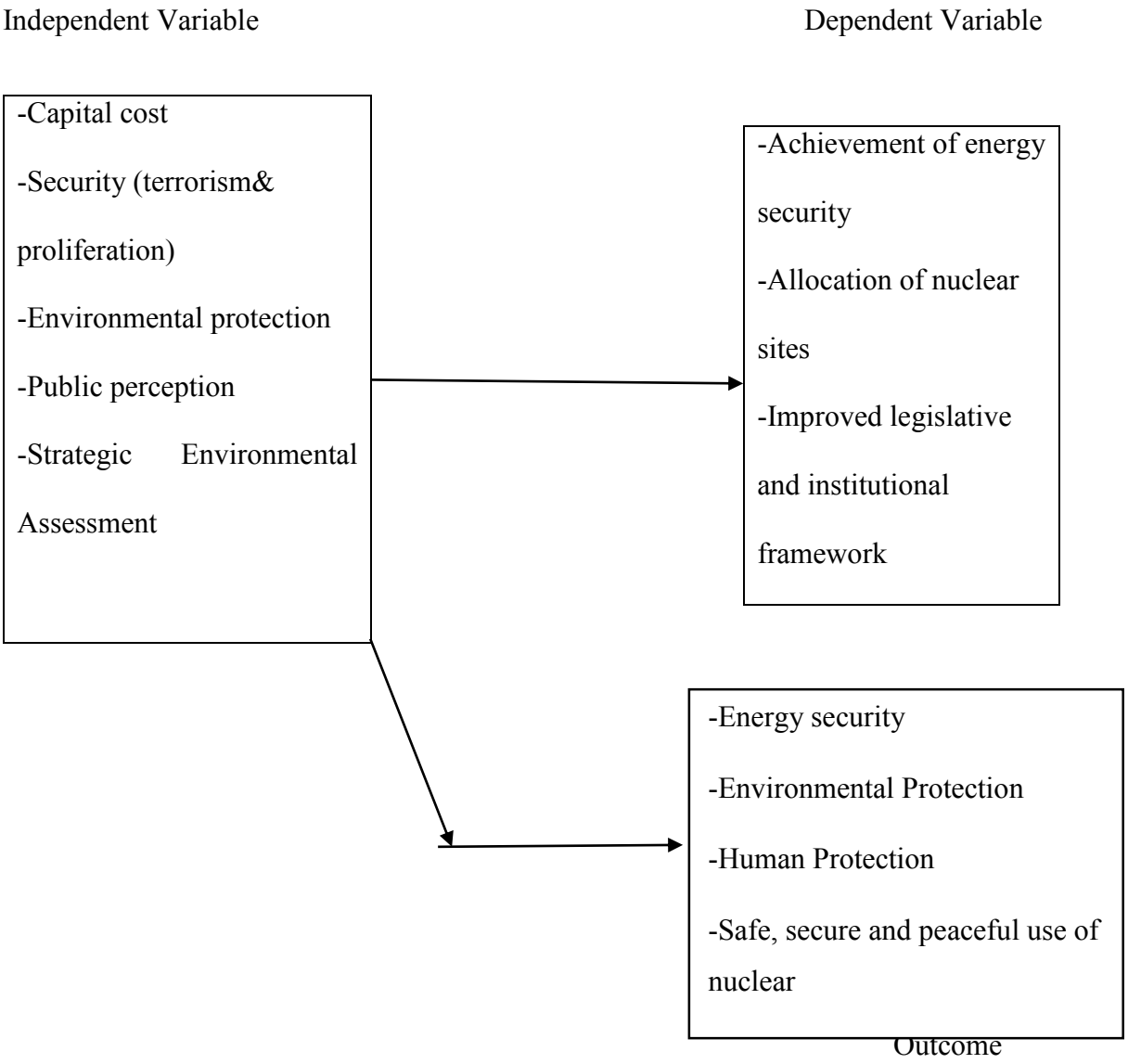

Figure 1 Conceptual framework

Source: @author, Christine Mududa 2021

The achievement of energy security, allocation of nuclear sites, and improved legislative and institutional framework rely on capital cost, security (terrorism and proliferation), environmental protection, public perception, SEA, and cost of power. Achieving energy security is difficult when

the price of power and capital cost increases since many will not afford it. High cost will deter the use of a specific source. Public perception and security (terrorism and proliferation) affect the allocation of nuclear sites, achievement of energy security, and improved legislative and institutional framework. The conceptual framework relates to the theoretical framework, which is energy security distinguished in dimensions that include availability, affordability, reliability, efficiency, and greenhouse gas emissions. This can be achieved through consideration of Articles 10, 42, and 69 of the Constitution. The conceptual framework addresses whether the current laws comply with environmental protection statutes of nuclear energy production.

CHAPTER TWO: LITERATURE REVIEW

2.0 Introduction

The chapter covers the literature reviewed on the role of nuclear energy in the fulfillment of electricity security for economic growth, the regulatory requirements for siting nuclear power plants, the gaps in the existing legislative and institutional framework for nuclear energy generation in Kenya and finally, the literature review gaps are identified. It also expounds on the reasons why Kenya needs nuclear energy and the environmental measures needed to govern the nuclear energy sector in Kenya that can take care of the environment and avoid harmful consequences that can be caused by the generation.

2.1 The Role of Nuclear Energy in the Fulfillment of Energy Security for Economic Growth in Kenya

Nuclear energy gives 12% to total electricity generation in industrialized countries, including those in Europe which have centrally-planned economies. In Africa and other developing countries, its role as an energy source is still minor.[1] Countries in Africa have unreliable electric energy that has not contributed to the economic development effort.[2]A look at Kenya's electricity generation mix insinuates that nuclear energy becomes critical as the rise and demand for power increases due to the accelerated investment in the economy. It is projected that in 2017-2037 the electricity demand

[1] Scalise, P.J, 'Policy images, issue frames, and technical realities: Contrasting views of Japan's energy policy development' (2013)

[2] Mwita, C., 'Regional integration and nuclear energy in Africa' African Security Review 21(2012)38-50 <https://www.researchgate.net/publication/272005274_Regional_integration_and_nuclear_energy_in_Africa> accessed 04 October 2021

will range from 1,754 MW to 9,790MW in the high case and 1,754 to 4,763MW in the low case.[3] Attainment of future energy demands could be jeopardized due to the postponement of planned investments in the energy sector. As per LCPDP, Kenya had initially planned to launch a 1,000 MV nuclear plant in 2022. However, such plans have been carried forward by at least fourteen years to 2036[4].

Kenya's energy demand was projected to rise consistently in recent years and thus the need to have diverse sources of energy to guarantee that the demand is effectively met. Among the projects undertaken under the Kenya Vision, 2030 flagship that gives rise to this demand include the standard gauge railway covering Juba – Lamu and Mombasa – Nairobi –Malaba, Kisumu, container terminal, city resorts in a location such as Isiolo, Ukunda, and Kilifi. The flagship project will also see the realization of energy-intensive projects such as iron smelting industries. However, the missing demand growth is due to ambitious demand projections that relied on an electric standard gauge railway line, industry growth, built resort cities and establishment of several special economic growths which did not kick-off[5] and led to the reduction of demand forecast projections in the LCPDP.

The central challenge of Kenya's energy sector is high costs and insufficient supply due to the energy mix that largely depends on climate as more than half of it depends on rain, and 13.2% depends on fossil fuel which is expensive. Kenya gets about 68% of its primary energy supply from biomass, charcoal, or wood fuel for the rural areas. At present, Kenya remains largely un-

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[3] Kariuki, M., 'Delivering Clean and Affordable Energy for All' (2021)2
[4] Vision 2030 Least Cost Power Development Plan 2017-2037 (72)
[5] Edwin Okoth, 'How too much Energy Generation Short circuited Kenya Power' (2020) <https://nation.africa/kenya/business/how-too-much-energy-generation-short-circuited-kenya-power-1925156> accessed 10 October 2020

electrified with only 63.8 percent of the population not connected to the grid, and 84 percent of rural communities do not have electricity connections.[6] The Last Mile Connectivity objective is to increase electricity connectivity to low-income groups through low voltage systems so that counties with low penetration rates benefit the most.[7] Having a diverse and resilient energy system or infrastructure guarantees energy security for a nation and its industries.[8] Kenya is still lagging with respect to energy security as has failed to exploit to full potential natural sources of energy inherent in the country, such as solar, hydro-power, geothermal, wind, bio, and biogas energy.[9] This is due to drawbacks that renewable energy presents for example solar energy panels are expensive, intermittent and its efficiency fluctuates.[10] Vast parcels of land are also needed for solar to be connected to the grid, just like the wind. It brings about the compensation aspect for the government to acquire land, thus an expensive exercise. Buying the batteries that powers the solar power is also expensive, making both the private sector and the government shy away from installing it.

The National Energy Policy, 2014 highlighted challenges facing wind energy in Kenya which included high upfront costs, high capital investment since most potential areas for wind energy generation are far away from the grid and load centres, competing interests in land use with other commercial activities, inadequate wind industries standards due to fast-changing technologies and

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[6] Magda Moner Girona et al., 'Energy for Sustainable Development' (2019) 129
[7] KPLC Environmental and Social Management Framework for Kenya Power's Last Mile Connectivity Programme (2014) 10
[8] IAEA Bulletin 54-1 March 2013

[9] I. Gitone 'Determinants of Adoption of Renewable Energy in Kenya' (2014) 16 <http://erepository.uonbi.ac.ke/bitstream/handle/11295/77819/Gitone_Determinants%20of%20adoption%20of%20renewable%20energy%20in%20Kenya.pdf?sequence=3> accessed 11 October 2020
[10] Clean Energy Ideas, '8 Disadvantages of Solar Energy' (2019) <https://www.clean-energy-ideas.com/solar/solar-energy/8-disadvantages-of-solar-energy/> accessed 11 October 2020

enhanced capacities for turbines. Hydro-power major challenge is the unreliable rain patterns, thereby straining its performance. Masinga dam was shut down twice in 2017 due to drought conditions.[11]Renewable energy is the best taking into consideration that they do not emit greenhouse gases, thus environmentally friendly. However, each has its own challenges that puts a strain in the efforts to harness them. Nuclear energy has the ability to meet this security given that the cost of generating nuclear power are less sensitive to variations in fuel prices than the cost for the fossil-fired electricity and uranium is available in many countries.[12] At the same time, small quantities are needed to run a reactor. A lot of electricity can be generated economically and it is a sustainable development technology which has been there for centuries and has excellent safety records, no pollution, competitive costs, and helps preserve valuable fossil resources for generations to come.[13]In the 2017 edition of the OECD's International Energy Agency World Energy Outlook report, nuclear capacity installation growth is estimated at over 25% from 2015 to 2040 with the increase concentrating in the Asian countries and Kenya is also planning to be part of these countries. The report states that this is due limiting the global temperature increasing in 2100 to 2 degrees Celsius which includes low carbon. This therefore means that nuclear electricity production will help in the reduction of global warming.

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[11] Michael Harris, 'Drought Straining Kenya's Hydroelectric Resources' (2018) <https://www.hydroreview.com/2018/02Julydrought-straining-kenya-s-hydroelectric-resources/#gref> accessed 11 October 2020

[12] Ibid

[13] Michael Harris, 'Drought Straining Kenya's Hydroelectric Resources' (2018) <https://www.hydroreview.com/2018/02Julydrought-straining-kenya-s-hydroelectric-resources/#gref> accessed 11 October 2020

NPP are costly to construct but fairly inexpensive to run. In most places, nuclear power competes with fossil fuels as a mode of power production.[14]There are countries where the cost of oil is cheap. However, in countries like Kenya, where the tax for fuel pushes the price to more than double the international rate, it would be viable to generate nuclear electricity. Nuclear energy has an advantage over other sources of energy such as wind and solar in the sense that it can avail energy for a stretched period of time. Solar and wind, for example, rely on environmental factors and therefore could be very limited from time to time, leading to decentralized configurations in terms of energy productions. Nuclear energy, therefore, guarantees the provision of electric power that can always support the national grid.[15]This is a major problem in SSA, where many are not connected to electricity due to a lack of base-load power capable of supplying the needed demand.

Compared to other forms of energy production, such as coal power, for example, less radiation up to one hundred times less is released to the environment. Among the reasons for the opposition of the use of nuclear power in energy production are the allegations of being unsafe and exposing humans to injury. In reality, the least human injuries are incurred with the use of nuclear power to produce energy[16]. The radiation caused by the NPP is not as intense as other sources of energy, it is the public perception that makes people believe that nuclear energy causes tremendous environmental and human radiation effects.

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[14]World Nuclear Association, '*Economics of Nuclear Power'* (2013)

[15] Benjamin Savacool 'Critically Weighing the Costs and Benefits of Nuclear Renaissance' (2010) 108 <https://www.tandfonline.com/doi/pdf/10.1080/1943815X.2010.485618?needAccess=true> accessed 24 October 2020

[16] A.J.O Ellis Jr. & G.P Shultz, 'Keeping the Lightson at America's Nuclear Power Plants' (2017) <https://www.hoover.org/research/benefits-nuclear-power> accessed 24 Octobe r2020

The high cost of constructing a nuclear power plant has made it difficult for most countries to construct a nuclear power plant. In Kenya, the estimation of constructing an NPP is Kshs. 500 Billion. However, Governments can subsidize capital costs through discounts. A 2015 study of 22 countries found that, at a discount rate of 10 percent, the median cost of both natural gas and coal was lower than nuclear energy. While at a discount rate of 3 percent, nuclear energy was the most economical option in all countries analysed.[17]

2.1.1 The relationship between Nuclear energy and environmental protection

The relationship between energy security and environmental protection first lies in balance the diverse energy market competitors and sustainable energy policy. This means that energy security considerations prevail over environmental ones. According to the IEA, the ability of a nation to significantly lower amounts of power supply disruptions shield it from economic vulnerability and outline energy security. To realize energy security, there should be reliable sources of power that should replace vulnerable sources.[18]

The 2007 Intergovernmental Panel on Climate Change Assessment report confirms the now known impact of fossil fuel use on climate change globally. However, there is no conclusive evidence on the impacts of natural and anthropomorphic energy in terms of GHG concentration. Further, there is no conclusive findings on the relationship between GHG concentration and climate change impacts as the research is still ongoing.[19] Sustainable development has become the driving force

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[17] D. Lurshina, N. Karpov et al., 'Why Nuclear Power Plants Cost so Much and What Can be Done About It' (2019) <https://thebulletin.org/2019Junewhy-nuclear-power-plants-cost-so-much-and-what-can-be-done-about-it/> accessed 24 October 2020

[18] IEA World Energy Outlook 2007

[19] IPCC Climate Change 2007: Synthesis Report, Summary for Policymakers

for the law to reconcile economic matters with environmental protection. Sustainable development's legal definition was articulated in 1987 by the Brundtland Commission and apprehended two notions that encompass both needs and limitations. Furthermore, the emerging notion of 'sustainable energy development' [20] shows how to grasp the opportunity to combine sustainable development with lasting energy security, by examining the latter in a broader context of human and environmental rights and needs.

Looking at the needs, the human-centred notion of future generations can be directly related to the right of people to an adequate standard of living, including a healthy environment, and development of the social and economic aspects. Article XIV of the African Convention on Conservation of Nature and Natural Resources provides that signatories have the mandate to put in place measures guaranteeing that development projects are backed by sound environmental policies and that the principle of sustainable development is not compromised. It further makes reference to the parties' duty to ensure adequate impact assessment on projects, plans, programs, strategies, and activities at the initial stages. Additionally, nations are required to put in measures monitoring and auditing these projects, plans, programs, strategies and activities to ensure they remain in line with the need to conserve natural resources and ecosystems.[21] This provision is fundamental in the realization of access to affordable and reliable energy given that in the process of implementing the nuclear power plant project, the effects to the environment should be mitigated so that the harm to the environment is reduced thus sustainable. In this respect, the 2002 World Summit on Sustainable Development's Plan of Implementation specifically calls on States

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[20] L.Price and M.D Levine, '*Production and Consumption of Energy' in Stumbling Toward Sustainability*' (2002) 63

[21] The African Convention on the Conservation of Nature and Natural Resources (Revised Edition) (2003) <www.kenyalaw.org> accessed 20 October 2020

to improve access to reliable and affordable energy services as one means of achieving the UN Millennium Declaration goal of halving the proportion of the world's people in poverty by 2015.[22]This creates energy security due to the fact that access to electricity is needed for poverty eradication.

Kenya has various provisions in the Constitution that protect the people and the environment. Article 10 provides for the participation of the people, good governance, and sustainable development as part of the national values and principles of governance. The Environmental Management and Co-ordination Act, 1999 defines sustainable development as the development that does not compromise the needs of the future generations. In *Nairobi ELC Petition 61 of 2018 Milimani Splendor Management Limited V. National Environment Management Authority & 4 Others,* Justice K. Bor stated that sustainable development is one of the national values and principles of governance under Article 10 of the Constitution, which bind all State organs, public officers and all persons whenever they apply or interpret any law or when they make or implement public policy decisions. In the court's view, these constitutional imperatives should guide the Respondents and the Nairobi Regeneration Committee, and the Multi-Agency Team as they reclaim the riparian reserves in Nairobi. This view shows how the Courts have been able to interpret and pronounce judgments in cases where the government, public officers, and all persons violate the provisions of the Constitution. It is important that the Government takes into consideration the provisions of the Constitution in order to avoid suits. In this spirit, the SESA

[22] World Summit on Sustainable Development Plan of Implementation (2002) <www.johannesburgsummit.org>.

final report on the nuclear power programme proposes the inclusion of strategies to deal with environmental issues.

Article 42 of the Constitution of Kenya provides for the right to a clean and healthy environment, which also touches on the right to life in instances where the actions of unclean or unhealthy environment cause death like in *Mombasa ELC Petition No. 1 of 2016 Kelvin Musyoka, Irene Akinyi Odhiambo & 8 Others V. The Hon. Attorney General & 7 Others* where the right to clean and healthy environment was violated and lead to deaths. In this case the petitioners brought a claim against the respondents due to the release of toxic waste from a lead-acid battery recycling plant established by the 7th Respondent on a property owned by the 8th respondent, leased for such purposes. The petitioners suffered various illnesses directly resulting from lead poisoning as the waste from the plant seeped through the villages. Additionally, 20 deaths directly resulting from the pollution were reported. An award of 1.3 Billion was given for violations, including those of their right to a clean and healthy environment, right to the highest attainable standard of health, right to clean and safe water, and the right to life. This illustrates that the right to a clean and healthy environment together with others are fundamental and should be considered during the physical development of the nuclear power plant in Kenya. The government should adhere to the Constitution and various statutes to avoid being sued, losing money in cases that could be used for other projects, and protect the lives of the people.

In *ELC Petition number 7 of 2017 (formerly HCCC Petition No. 24 of 2017)- Castle Rock Gardens Management Limited v the Attorney General, The Cabinet Secretary Ministry of Environment and Natural Resources, The County Government Executive Committee Member for Water, Energy, Forestry, Environment, and Natural Resources, County Government of Nairobi, National*

Environment Management Authority and Nairobi Water and Sewerage Company, the Petitioner sought a declaration that it was entitled to a clean and healthy environment and that the Respondents were obligated by Articles 42, 69, and 70 of the Constitution to eliminate all processes and activities likely to pollute River Kirichwa and the environment. It was argued that the respondent should be responsible for stopping all pollution sources into Kirichwa River, such as raw sewage or waste directly being disposed into this river. The court directed the Respondents to survey the entire Kirichwa River from its source to determine the riparian reserve and restore it to the state it was in before the developments were carried out along River Kirichwa. The 3rd Respondent in this petition was directed to perform its obligations under the law and ensure that the riparian reserve on either side of Kirichwa River was left free and uninterrupted so that sewer lines and maintenance holes could be laid out and maintained for purposes of draining sewage and waste from all the developments abutting Kirichwa River. This case shows that the courts are willing to enforce judicial review to protect the people and the environment; therefore, the construction of the nuclear power plant should be done to follow the provisions of the law.

Coastal Nuclear Power Plants that release heated water into the ocean cause coral bleaching, which is the home of over 2 million aquatic species changing the biodiversity of both original and invaded locations.[23] Article 69 of the Constitution obligates the State to protect genetic resources and biological diversity. The State should use technology that does not release heated water into the ocean to protect the biodiversity or put mitigation measures if such a technology is used to ensure genetic resources and biodiversity are protected. This also touches on the aspect of sustainable

[23] Brandon Clark, 'Thermal Water Pollution from Nuclear Power Plants' (2019) <http://large.stanford.edu/courses/2019/ph241/clark1/> accessed 20 October 2020

development since if the genetic resources and biodiversity are protected, the future generation will be able to see and use them. The need to ensure sustainable development informs the provision of Article 69 of the Constitution. There is need to give adequate protection to the environment, ensuring the current generation make use of the available environmental resource in a manner that preserves them for use and enjoyment by future generations.[24]

Environmental risks associated with nuclear plants can be classified into two categories, risks emanating from daily exploitation of the environment or from what can be termed a catastrophic failure.[25] On the former, broad geographical locations around the plants are exposed to acute danger due to release of radioactive toxins into the environment. The use of water and soil exposes individuals to such toxins as there is a high probability of the same being contaminated. Further, land in such areas becomes inhabitable. In history, Fukushima and Chernobyl are examples of such acute disasters.[26] Such disasters can be prevented through effective radioactive waste management, which entails actions shielding workers and operations within the plant from imprudent radiation and possible contact with radionuclides.[27] There are positive indications through feasibility studies within the nuclear industry with respect to effective and efficient disposal of long-live high-level radioactive waste; with geological disposal mooted.[28] In the U.S.A and Russia, geological disposal

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[24] K. Muigua and F. Kariuki, 'Sustainable Development and Equity in the Kenyan Context' Kenya Law Review Vol IV(2012-2013) <http://kenyalaw.org/kl/index.php?id=1906> accessed 20 October 2020

[25] Dean Kyne & Bob Bolin, 'Emerging Environmental Justice Issues in Nuclear Power and Radioactive Contamination' International Journal of Environmental Research and Public Health Vol. 13(7) (2016) <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4962241/> accessed 20 October 2020

[26] Ibid

[27] William Lennemann, 'Radioactive Waste Management' IAEA Bulletin-Vol .18, NO. 5/6

[28] M.V Ramana 'Nuclear Power: Economic, Safety, Health and Environmental Issues of Near Term Technologies' Annual Review of Environment and Resources (2009) 142 <file:///C:/Users/CHRISTINE/AppData/Local/Packages/Microsoft.MicrosoftEdge_8wekyb3d8bbwe/TempState/Downloads/Nuclear_Power_Economic_Safety_Health_and_Environme%20(1).pdf> accessed 24 October 2020

has been embraced, with high-level nuclear waste wrapped in glass cement and lead; these are then buried deep into the ground; deep as practically possible.[29]

Several approaches are presently employed to meet the environmental concerns related to nuclear energy production worldwide. In SA, the metal and concrete drums are utilized in storing peripheral waste and contaminated clothing, considered to be low-level atomic waste. The metal and concrete cases are stored at a specific waste site in Vaalputs, Northern Cape. Whereas high-level waste is stored near the reactors that produce them, the South African Nuclear Energy Corporation (NECSA) is making plans to have the same disposed deep underground as opposed to current practices of reprocessing and recycling.[30] The IAEA Disposal of Radioactive Waste, Specific Safety Requirements No. SSR-5 provides that the government, regulatory body, and the operator have responsibilities. The government is mandated to put in place a framework geared towards ensuring safety with respect to the use of nuclear energy. Among the key roles to be executed within such governmental, legal, and regulatory frameworks include assessment of waste disposal facilities, outlining measures for the development and licensing of facilities, allocating responsibilities, sourcing financial resources, giving regulatory guidelines on the creation and operation of waste disposal facilities.[31] In addition, up-to-date regulatory requirements and the procedures on attaining them are expected to be furnished by the regulatory bodies with respect to disposal facilities for radioactive waste. Conditions are also to be set for the development, operation, and closure of such facilities as well as monitoring to guarantee compliance.[32]

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[29] Sipho Kings, 'What Does SA Plan to do with its Toxic Nuclear Waste?' (2016) <https://mg.co.za/article/2016-09-19-what-sa-will-do-with-highly-toxic-nuclear-waste-is-a-secret-as-is-the-mooted-nuclear-fleet/> accessed 25 October 2020

[30] Ibid

[31] The IAEA, 'Disposal of Radioactive Waste, Specific Safety Requirements' No. SSR-5(2011)17

[32] The IAEA, 'Disposal of Radioactive Waste, Specific Safety Requirements' No. SSR-5 (2011)18

The duty to guarantee the safety of waste disposal facilities is placed on the operators of such facilities. They are to conduct safety assessments, maintain safety cases, and conduct all activities incidental to site selection and evaluation, design, construction, operation, closure, and surveillance after closure. These activities are to be executed within existing national regulatory frameworks, as established by mandated bodies.[33] In Kenya, section 73-88 of the Nuclear Regulatory Act, 2019 provides for the management of active waste. Section 74 provides that radioactive waste and spent fuel within or outside a facility lies with the holder of the relevant authorization, which shall be issued by the Kenya Nuclear Regulatory Authority shall issue. Having the legal and regulatory framework in place is a good step towards achieving IAEA standards. There are other issues that are pending, like having regulations on licensing conditions, classification of radioactive waste, and long-term management of radioactive waste. It can also be noted that it is prudent to deal with radioactive waste separately due to technicalities involved with it. A country like France, which produces 75% of its electricity from nuclear plants,[34] has a a regulator that strictly deals with radioactive waste management. This gives the regulator the time to concentrate on radioactive waste management, which can be a ticking time bomb if not taken care of properly.

Article 69 of the Constitution establishes systems of EIA, EA, and those that monitor the environment. Section 68 of the Environmental Management and Coordination Act provides for environmental audit, while section 69 provides for monitoring. These provisions ensure that the

[33] Ibid 9

[34] Stéphanie Tillement & Nicholas Thiolliere, 'Nuclear Power in France: Imagining the Industry's Future' (2019) <https://theconversation.com/nuclear-power-in-france-imagining-the-industrys-future-125914> accessed 01 November 2020

operation of projects is monitored to determine effects on the environment. Both the regulator and NEMA should be capacitated so that they are able to determine the effects to the environment.

In Kenya, geothermal contributes to 47 percent, hydro-power 30.1 percent, and conventional thermal 20.6 percent.[35]A negative aspect of the energy sector in Kenya is constant power outages, the use of fossil fuels in hydroelectricity production, and over-reliance on biomass.[36] Embracing nuclear energy will significantly lower costs incurred in energy generation since the need to purchase fossil fuels which are often subject to price fluctuations will be eliminated. The costs of electricity will subsequently go down.[37] Another significant nuclear energy is power capacity, with 50,000 kWh produced by just a kg of uranium. On the contrary, coal and wood produce just 5 kwh and 1kwh respectively per kg.[38] Nuclear power is clean, safe, reliable, compact, competitive, and practically inexhaustible[39] therefore providing the energy security needed for the development of the Kenyan economy.

2.1.2 Public Perception and Nuclear Power Plants

Nuclear energy has the promise to offer the capability to provide energy in the most cost-effective way and on the other hand, it is feared for deadly consequences due to radioactive wastes and nuclear power plant accidents. The Chernobyl and the Fukushima nuclear tragedy enlighted the world on the risks of nuclear energy. The operation of NPPs requires technical, advanced,

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[35] Magda Moner Girona et al. 'Energy for Sustainable Development' (2019) 130
[36] M. Ikaria, 'Trade in Environmental Goods and Services' (2009)
[37] Jarkko Ahokas, 'The Role of Nuclear Power in the Future Energy' 2015 (24)

[38] Kohl, K., 'Uranium Price Outlook' (2009) <https://www.energyandcapital.com/articles/uranium-price-outlook/72034> accessed 23 July 2020

[39] Comby B. 'The Benefits of Nuclear Energy' *(*2006) <http://ecolo.org/documents/documents_in_english/BENEFITS-of-NUCLEAR.pdf> accessed 23 July 2020

commercial, institutional, and legal capacities.[40] Even the most sophisticated countries can scuffle to manage nuclear power when things go wrong, as highlighted by the Fukushima Daiichi Nuclear Power Station; therefore, less developed countries, such as Iran with its Bushehr facility, can create serious concerns within their boundaries and their regions when they adopt nuclear energy.[41] The management of nuclear wastes is a monumental challenge taking years to deal with in removing radioactivity from the reactors. Nuclear reactors have expiration dates and have to be replaced. The plant has a short lifespan and is expensive to build, pushing the need to quickly recover the money, which tends to push up the cost of electricity generated.[42]In addition, there are targets of terrorists and to add to the problem of a country like Kenya is the raw material uranium that Kenya has to mine.

The government officials strongly defend the nuclear project. There are questions about how a country whose major cities, Nairobi, Kisumu, and Mombasa, have failed to handle minor fire disasters and basic household waste will effectively deal with toxic wastes, which are the by-product of nuclear power generation.[43] This perception needs to be addressed by the Government through equipping the public with sufficient information for them to understand the concepts of nuclear electricity production. It can be done through compulsory periodic public engagement and civic education to enhance transparency of operations and reporting. This was even an observation

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[40] P. Hoodbhoy, Y. Zhou & S. Amir, 'Bulletin of the Atomic Scientists *Needed: Ability to Manage Nuclear Power'* (2014) <https://thebulletin.org/roundtable/needed-ability-to-manage-nuclear-power/> accessed 13 February 2019

[41] Ibid

[42] Poorhashemi, Seyed Abbas, et al., 'The Role of International Environmental Laws and Regulations in Peaceful Use of Nuclear Energy' (2013)

[43] Collins Omulo, 'Kenya's Nuclear Quest: A Case of Extreme Optimism' article available on the Nation Newspaper dated 2nd January 2018.

by the National Assembly in the public participation report on Nuclear Regulatory Bill, 2018.[44] Public perception varies from one country to the other depending on the availability of information. Mberia concluded that in Kenta the Government's action to address concerns and availability of information about nuclear power production will decrease negative perceptions. [45]

2.1.3 The Assessment of Utility of Nuclear Energy as a Source of Electricity Production

Kenya's challenges in the energy segment include: reliance on imported fossil fuels, low electrification rate, incapacity of the power utility agency to fix all clienteles who make application for connection to the national grid, transmission inefficiencies , high cost of rural electrification, demand for electricity outstripping generation capacity and frequent power outages.[46] The use of nuclear power has reduced carbon dioxide emissions by over 60 gigatonnes which is nearly two years' worth of global energy-related emissions for over the past fifty years.[47]This means that without nuclear energy the world would be grappling with 20% higher emissions from electricity production.[48]Nuclear is a clean source of energy and assists in climate change mitigation.

Nuclear electricity production satisfies the need for predictable and economic base-loaded electrical systems which run most of the time and do not fluctuate in power during the day

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[44] The National Assembly *Report on Nuclear Regulatory Bill, 2018 (National Assembly Bill No. 27)* (2019) 25 <http://www.parliament.go.ke/sites/default/files/2019-06/Report%20on%20Nuclear%20Regulatory%20Bill%2C%202018.pdf> accessed 30 October 2020

[45] National Environmental Management Authority *Strategic Environmental Social Assessment Report for Kenya's Nuclear Power Programme* (2020) 131

[46] K., Muigua, 'Delivering Clean and Affordable Energy for All' (2021)2

[47] IEA *Nuclear Power in a Clean Energy System* (2019) Abstarct https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

[48] IEA *Nuclear Power in a Clean Energy System* (2019) 9 https://www.iea.org/reports/nuclear-power-in-a-clean-energy-system

cycle.[49]Nuclear is competitive given that the other cost factors which are; operation and maintenance , fuel and capital improvements are significantly less for nuclear.[50] Other low-carbon techniques of electricity generation require more land per megawatt as compared to nuclear power stations. A research by Entergy Arkansas approximates that the modern wind and solar plants require 108,000 acres and 13,320 acres of land respectively as compared to nuclear that need 1,100 acres in order for all the plants to produce 1,800 megawatts.[51] This makes nuclear energy affordable given that the land needed for construction of a nuclear plant costs less than that needed for other renewable energy. Compensation of land owners is usually expensive when the land needed is vast. It is also reliable giving it the capacity to spur industrialisation in the country. When nuclear energy is added to the grid, it can provide a boost that is needed for socioeconomic growth.

2.2 Regulatory Requirements for Nuclear Power Plants Sites in Kenya

"The IAEA Safety Standards Series No. SSG-35 Site Survey and Site Selection for Nuclear Installations Specific Safety Guide" sets out clear guidelines which must be followed when conducting site survey as well as selection with respect to short-listed sites for a probable erection of a NPP.[52] Among issues addressed by the guide include safety, planning economics, impact on communities, environmental impact and public opinion on the planned projects.[53] Kenya, being a

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[49] N., Diaz, 'Nuclear Energy is Clean, Reliable and Affordable. Not to Mention Easy to Manage'(2011) <https://www.americasquarterly.org/fulltextarticle/nuclear-energy-is-clean- reliable-and- affordable-not- to-mention-easy-to-manage/

[50] Ibid

[51] Strata *The Footprint of Energy: Land Use of U.S Electricity Production* (2017)7 <https://docs.wind-watch.org/US-footprints-strata-2017.pdf> accessed 30 September 2021

[52] International Atomic Energy Agency *Site Survey and Site Selection for Nuclear Installations* IAEA Safety Standards Series No. SSG-35 (2015) 3 <https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1690Web-41934783.pdf> accessed 10 October 2020

[53] International Atomic Energy Agency *Site Survey and Site Selection for Nuclear Installations* IAEA Safety Standards Series No. SSG-35 (2015) 4 <https://www-pub.iaea.org/MTCD/Publications/PDF/Pub1690Web-41934783.pdf> accessed 10 October 2020

member of the IAEA, needs to be guided by the safety guide and make considerations including public participation and environmental impact nuclear power can cause, as mentioned in the guide. Countries that want to construct nuclear power plants must have a legal framework, regulatory competence, financial stability, technical competence, operational skills, and attitude according to the IAEA standards.[54] These standards are vital since Africa has a problem maintaining projects. The current energy sources like hydro-power and thermal have plants built in the 1970s. Still, they have never been born, thus operating below the required capacity. There is also a lack of engineers who can maintain the existing infrastructure.[55] The site survey scope includes seismology, demography, environmental effects, geology& tectonic, heat removal capability, hydrology, integration into the electric system, legal aspects, meteorology, nuclear safety, and radiation protection aspects, and public acceptance. Site survey is divided into geographical analysis & singling out prospective sites, screening of probable sites, selecting of the sites & comparing the candidate sites.[56]The two processes that occur before a suitable location is selected are the siting process and the site evaluation process. The siting process has two stages, i.e., the site survey and site selection.[57]While the site evaluation process has four stages which includes site selection, site characterization, pre-operational and operational stage,[58]as discussed below.

[54] International Atomic Energy Agency *Managing the First Nuclear Power Plant Project* (2007)36
[55] Abutu A., 'Is Africa Ready for Safe Nuclear Power?' Scidevnet (2011) <https://www.scidev.net/global/features/is-africa-ready-for-safe-nuclear-power-1/> accessed 03 October 2021
[56] International Atomic Energy Agency *Managing the First Nuclear Power Plant Project* (2007)37
[57] International Atomic Energy Agency Safety Standards Series No. SSG-35 *Site Survey and Site Selection For Nuclear Installations* (2015) 6
[58] Ibid 7

2.2.1 Site Survey

In this stage, one or more candidate sites are identified after many regions have been examined.[59]During this stage, planning and documenting activities to be performed, use of properly qualified personnel, and establishment of a record system in accordance with the IAEA safety series No. 50-C-QA, 78 code is done.[60] This process culminates with a site survey report required for early site approval and limited work authorization before the construction permit.[61] Kenya has not come up with a specific regulation or a code for this process but there are international standards as indicated above which should be taken into consideration when being drafted. Section 57A of EMCA provides that all policies, plans, and programs for implementation must be subjected to SEA. Nuclear power production is a programme thus, the Strategic Environmental and Social Assessment was conducted and final report was done in March 2020. Site analyses have been done for Lake Victoria Basin, Lake Turkana Basin, and the Coastal Region.[62] According to the report, the Coastal Region is the best, while Lake Victoria Basin and Lake Turkana Basin are at par. Kenya is making progress towards having a site.

2.2.2 Site Selection

The second stage of the siting process, site selection, includes part of the site evaluation process and is the overlapping stage between the siting process and the site evaluation process.[63] One or more preferred candidate sites are selected after investigation of a large region, rejection of

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[59] *Supra* note 136
[60] IAEA Assurance for the Survey, Evaluation and Confirmation of Nuclear Power Plant Sites (1987) 19
[61] Khattak M.A., Omran A.B.A et al., 'Siting Consideration for Nuclear Power: A Review' Open Science Journal 2(3) (2017) 13
[62] Nuclear Power and Energy Agency *Strategic Environmental and Social Assessment For The Kenya's Nuclear Power Programme Final Draft Report* (2020) vii
[63] International Atomic Energy Agency Safety Standards Series No. SSG-35 *Site Survey and Site Selection For Nuclear Installations* (2015) 8

unsuitable sites, and screening and comparison of the remaining sites.[64] Section 56(2)(f) of the Energy Act, 2019 provides that the Nuclear Power and Energy Agency shall identify appropriate sites in Kenya for the construction of nuclear power plants and their related amenities. NuPEA is in the process of doing this since the site survey has already been done. For this to be achieved, other factors have to be taken into consideration. Public acceptance is needed during this stage because without it, the authorities cannot plan on-site selection.[65] In site selection, areas with the minimum surface faulting and earthquake are preferred, and regions with stable rocks and surface soils such as dense sands are considered suitable.[66] The SESA report on Nuclear Power Plant in Kenya explains that the appropriateness for nuclear installation site ought to be assessed with regard to the social and environmental features and its surrounding that can determine the effect of unconfined radioactive material on individuals and environment.[67] This ensures that the nuclear power plants do not cause harm to the community and the environment, thus the protection.

2.2.3 Site Characterization

This stage is divided into verification and confirmation. During verification, the suitability of the site is validated according to predefined site exclusion benchmarks while confirmation involves determination of features of the site essential for the objectives of analysis and detailed design.[68]Finalization of the deriving of the design basis due to external events is done. This process leads to the drafting of the site evaluation report as a basis for the 'site' section of the preliminary

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[64] P. Gunglapalli, 'Site Selection Criteria for Nuclear Power Plants and Evaluation of Site Specific Design Basis Earthquake Parameter*s'* (2008) 1
[65] *Supra* note 140
[66] Ibid 17
[67] Nuclear Power Energy Agency Strategic Environmental and Social Assessment Report for the Kenya's Nuclear Power Programme Final Draft Report (2020) 18
[68] Ibid

safety analysis report for the nuclear installation.[69]The following were taken into consideration in Kenya when the candidate sites were analysed; biodiversity richness, meteorology; hydrology; environmental risks; demographics and society safety; electricity grid infrastructure, and transport support infrastructure.[70] This may fall under the site surveying since a site selection has not been done. After site selection is done, the site characterization will be considered.

The IAEA provides the following characteristics in the siting process, which Kenya should take into consideration when the time comes;

Data on

a. Coastal flooding including tsunamis;
b. Human induced events;
c. meteorological;
d. population, land use, water use and environmental impacts;
e. river flooding;
f. Fault displacement;
g. Geology;
h. Geotechnical;
i. Hydrogeology;
j. Seismology;
k. Volcano-logical.[71]

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[69] International Atomic Energy Agency Safety Standards Series No. SSG-35 *Site Survey and Site Selection for Nuclear Installations* (2015) 8

[70] Nuclear Power Energy Agency Strategic Environmental and Social Assessment Report for the Kenya's Nuclear Power Programme Final Draft Report (2020) vii

[71]Ibid 25

The Kenyan law does not have a provision for site characterization. However, regulations should be drafted in order to include them to make sure that standards are met, and the environment is safeguarded. The SESA Final Report on NPP provides that hydrology, geology and topography, biodiversity, human population and human safety, environmental risks, power grid infrastructure, and transportation sustenance infrastructure shall be considered during the site characterization.[72]

2.2.4 Pre-operational Stage

The previous stages inform this stage by refining the assessment of site characteristics. Data obtained from the site allow a final assessment of simulation models used in the ultimate design of the foundation and superstructure.[73]

The Constitution of Kenya provides for public participation as part of values and principles according to Article 10 and in Article 69(1)(d) it provides for participation of the people in the management, protection, and conservation of the environment. IAEA advises that public acceptance is key in the process of constructing a nuclear power plant. An information collection programme aimed at both the general public and the residents around the site of the NPP should be planned and executed expeditiously.[74]There needs to be a programme for public consultations on nuclear energy even before a site is selected to have public acceptance.

The SESA final report on Nuclear Power Programme has recommended that EIA for Nuclear Power and Radioactive Facilities regulations need to be done to accommodate nuclear energy

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[72] Nuclear Power Energy Agency Strategic Environmental and Social Assessment Report for the Kenya's Nuclear Power Programme Final Draft Report (2020) 19

[72] Ibid

[73]P. Gunglapalli, 'Site Selection Criteria for Nuclear Power Plants and Evaluation of Site Specific Design Basis Earthquake Parameters' (2008)1

[74] International Atomic Energy Agency *Managing the First Nuclear Power Plant Project* (2007)37

production, environmental audit, and environmental monitoring. These aspects will be relevant to the production of nuclear energy to ensure that radiation limits are not exceeded, water is not contaminated, and generally, the environment and the people are protected.

2.2.5 Operational Stage

Selected investigations are pursued over the plant's lifetime to ensure that the variation of engineering properties does not vary significantly during the plant's operating life.[75]During this stage, it is important to ensure that workers and those within the area are protected. The Occupational Safety and Health Act, 2007 purpose is to secure the safety, health, and welfare of persons at work together with the people affected by activities of those individuals at work. This will therefore ensure that persons working at the nuclear plants are protected against any harm that may be caused by nuclear energy production and at the same time protect those in the surrounding area of the plants.

However, it should be noted that this law was passed when nuclear energy production was not taken into account; therefore, it should be mainstreamed to the IAEA safety provisions to realize the safety provisions. The above processes are done in order to ensure that the environment and people are safe during the lifespan of the nuclear power plant despite the challenges that may occur during power production.

2.2.6 Participatory Land Use Planning

Article 67(2) (h) of the Constitution of Kenya, 2010, provides that the National Land Commission is mandated to monitor and have oversight responsibilities over land use planning throughout the

[75] Ibid

country. In so doing, other provisions of the Constitution should be considered, thus participatory land-use planning. Article 66 of the Constitution provides for the regulation of land use by the State. The Fourth Schedule Part 1 paragraph 21 provides for general principles of land planning and the coordination of planning by the counties, while the Fourth Schedule Part 2 paragraph 8 provides for county planning and development. The current generation of nuclear technology, primarily small to medium-sized modular reactors (SMR), is inexpensive and small in size, reducing the demand for land use.[76] Nuclear power plants need land in which they have to be constructed thus, communities and the government will have to work together to avail land needed for the construction of the plant. The Community Land Act, 2016 provides for the identification, safeguarding, and registration of community land rights. The Act provides for special rights and entitlement in the community land, conversion of community land to public land and environment, and natural resources management. The communities that live in the area where the nuclear power plant will be constructed must first have to accept that the plants will be constructed within their community. This will involve access to information, dissemination of information, and consultative forums for the community and the public to understand and eventually accept the construction of the plants. The concerns to be deliberated publicly are the role of environmental and health issues, waste management and disposal policies, and details on possible harmful results of usual operation of NPPs and abnormal events.[77] Section 55 of the Physical and Land-use Planning Act, 2019 provides for development control objectives which includes to protect and

[76] Pamela, L., 'Africa Pushing a Synchronized Nuclear Agenda' Power Engineering International <https://www.powerengineeringint.com/nuclear/africa-pushing-a-synchronized-nuclear-agenda/> accessed 04 October 2021
[77] International Atomic Energy Agency Safety Standards Series No. SSG-35 *Site Survey and Site Selection for Nuclear Installations* (2015) 37

conserve the environment, promote public safety and health, and promote public participation in physical and land use development decision-making. This covers the scope envisioned by the IAEA since development includes nuclear power energy production. The NPP should conform to the demands of the Physical and Land Use Planning Act, 2019 and land use planning. There is special significance on the need to undertake the plan through a participatory process that requires the involvement of stakeholders in the planning process.[78]

Matters on the use of land and natural resources so as to achieve optimal utilization are addressed by the Sessional Paper No. 1 of 2017, wherein guiding principles for land and natural resources are outlaid. These include effective and proper management to guarantee public good and general interest, proper planning in line with the principles of sustainable development, promotion of proper and effective development of land, enhancing the conservation of the environment, mitigating risks associated with poor use of land, and natural resources, effective land planning at every level, effective resolution of conflicts related to land use and proper delimitation as regards to the use of land in the country.[79] Regulation 19(g) of the Physical and Land Use Planning (Classification of Strategic National or Inter-County Projects) Regulations, 2019, provides nuclear energy facilities as a project of strategic national or inter-county importance. The Nuclear Power Plants will be subjected to these policies, which integrates land use planning with environmental considerations, thus good for the environment and future generation.

The composition and operation of the NPP depend on the site characteristics; the site-derived risks have to be considered in the plant design basis, and the site itself has to bear the risks and

[78] Nuclear Power and Energy Agency, 'Strategic Environmental and Social Assessment Report for the Kenya's Nuclear Power Programme' (2020) 66
[79] National Land Use Policy (2017) 4

detriments coming from the plant.[80] The site has to provide needed requirements such as rejected and decay heat sinks, availability of electrical power supplies, good communications, and effective emergency management, including the evacuation of nearby residents.[81] This means that the geographical area is key since not any land can be used for the erection of a nuclear power plant. Technical persons need to be involved to ensure that the site chosen has the considerations necessary for the plant failure to which messes may befall the nuclear power plant.

Country requirements for siting of NPP would be different for every country where control is done by the regulatory bodies.[82]NuPEA conducted SESA for the nuclear power plant in Kenya, and three candidate site regions have been identified which include the Coastal Region, the Lake Victoria Basin, and the Lake Turkana Basin. The coastal region emerged the best amongst the three, while Lake Victoria Basin and Lake Turkana Basin are at par. Tana River is the most preferred site, while Marsabit and Siaya emerged the best in their regions.[83]

The Nuclear Regulatory Act, 2019 provides that a site evaluation report shall be provided by the person applying for a site authorization for NPP. This will raise issues given that the Government is the entity that intends to construct NPP; therefore, this section intends that it will do a report and submit it to another government authority. The government is the same despite the various

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[80] Alonso A., 'Site Selection and Evaluation of Nuclear Power Plants' (2014) <https://www.sciencedirect.com/science/article/pii/B9781845699734500188> accessed 25 July 2020

[81] Ibid

[82] Muhammed A.K. Aisha U. et al, 'Siting Consideration for Nuclear Power Plant' (2017) <https://www.researchgate.net/publication/322487678_Siting_Consideration_for_Nuclear_Power_Plant_A_Review > accessed 25 July 2020

[83] *NEMA Strategic Environmental and Social Assessment Report for Kenya's Nuclear Power Programme Final Draft Report* (2020) <https://www.nema.go.ke/images/Docs/SEA%20Reports/Final%20Draft%20SEA_NPP_26th%20March%202020-min.pdf> accessed 10 October 2020

agencies given different roles. It will make sense if private entities are permitted to construct the plants buy due to the capital costs, the construction of NPP is mostly Government oriented. Therefore, there is no independent watchdog, given that the Kenya Nuclear Regulatory Authority shall provide authorization for the NPP.

2.3 The Gaps in the Existing Legislative and Institutional Framework for Nuclear Energy Generation in Kenya.

2.3.1 International Nuclear Policies and Law

The government has the responsibility and primary duty to put in place statutes creating an independent nuclear energy regulatory body, outline supporting policies, create standards and measures for nuclear safety, for the purposes of ensuring adequate effective protection against the adverse effects of nuclear waste.[84] The procurement process, the public and stakeholder involvement, licensing requirements, and the need for contractor organizations to maintain a qualified workforce are among the legal requirements apart from the obvious safety and security requirements discussed when considering the erection and commissioning of a NPP.[85]

Kenya has ratified many international instruments within the international nuclear regime which include nuclear safety, security, and safeguards. That being said, it is in order that accessions be in respect to some integral instruments touching on energy production and nuclear energy production. These include: "The Convention on Early Notification of a Nuclear Accident (the

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[84] IAEA *Governmental, Legal and Regulatory Framework for Safety, General Safety Regulations- Part 1 IAEA Safety Standards Series, GSR PART 1* (2010)

[85] International Atomic Energy Agency *Construction and Commissioning of Nuclear Power Plants* <https://www.iaea.org/topics/construction-and-commissioning-of-nuclear-power-plants> accessed 12 December 2018

Early Notification Convention)," "The Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the Assistance Convention)," "The Convention on Nuclear Safety" (the CNS) and "The Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management" as endorsed by the IAEA's Milestones Approach on the legislative and regulatory framework infrastructure issues respectively.[86] The Milestones Approach has set out strategies that a State may adopt to holistically assess its status (level of development) concerning 19 infrastructure issues as it embarks on the development of its nuclear power programme.

The IAEA Statute indicates the 3 pillars of the institution's work, which are technology transfer, nuclear verification and security, safety, and technology transfer.[87]The Chernobyl nuclear power plant in 1986 exposed deficiencies and gaps in the international legal and regulatory framework established to govern the safe and peaceful use of nuclear energy.[88] It provided the impetus for increased international cooperation on the global nuclear safety regime. The envisaged system could be founded on four principal elements, which are, the adoption of binding and non-binding international legal instruments; an all-inclusive set of nuclear safety standards that exemplify good practices relating to nuclear safety; a series of international safety advisory assessments and services; and the establishment of the national legal and regulatory framework needed to execute strict safety measures.[89]

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[86] IAEA *Milestones in The Development of A National Infrastructure For Nuclear Power* Nuclear Energy Series No. NG-G-3.1 (2007)

[87] Article 3 of the IAEA Statute

[88] Rautenbach ea *Joint Report* 7.

[89] Rautenbach ea *Joint Report* 8.

Countries that generate nuclear energy like South Africa have a robust policy and legal framework guided by the IAEA legal framework. Those who intend to generate nuclear electricity like Kenya need to be guided by the IAEA legal framework and best practices. Kenya has taken a step towards achieving this by enacting the Nuclear Regulatory Act, 2019. However, some international principles have not been included in the legislation, like the compensation principle. The first NPP may be constructed around 2027 therefore, there is time to critique the Act and make necessary amendments.

The SESA report for Nuclear Power Programme provides progress towards adopting international legal structures as an environmental issue policy recommendation. This position will be guided by the international nuclear law, which Kenya has taken into consideration since it is a member of the IAEA and at the same time has ratified various nuclear energy treaties and conventions.

The principle of safety is the first of the cross-cutting principles. It is further divided into the principles of prevention, protection, and precaution.[90] The prevention principle spells out the deployment of wariness and foresight in order to inhibit damage that might be caused by the use of nuclear technology and decrease any unfavorable effects arising from use or misuse accidents. The protection principle complements the prevention principle and it calls out for a balance of the social risks and benefits related to the use of nuclear technology. Priority must be given to public health, safety, security, and the environment when there is a risk that outweighs the benefit of an activity.[91]

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[90]De Pompignan D, 'Law on the Peaceful Uses of Nuclear Energy: Key Concepts' (2007) Nuclear Law Bulletin 49

[91]Adorno R., 'The Precautionary Principle: A New Legal Standard for a Technological Age' (2004) Journal of International and Business Law 25

Entities that produce, distribute and use nuclear energy are governed by the second categories of principles. In this group, the principle of independence or accountability establishes an independent regulatory authority whose responsibility is to enforce nuclear law according to the international nuclear legal regime without intrusion from institutions engaged in development or advancement nuclear energy. Kenya took these principles into account while drafting the Nuclear Regulatory Act, 2019. However, having a single institution deal with all aspects of nuclear can deter it from being analytical in doing its job. The liability principle states that in the event of misuse or an accident the licensee is responsible party given that the authority to conduct the specific nuclear is given to them.[92] The principle of transparency and participation requires developing and regulatory nuclear entities to provide information in respect of the use of nuclear energy and in particular events and unusual happenings that could impact public health, safety and environment.[93]

Specific nuclear activities principles are non-proliferation or the security principle, while universal principles such as the sustainable development principle, the compensation principle, and the international cooperation principle exist as an outcome of comprehensive world-wide reflection. The compensation principle requires that victims of nuclear accidents be compensated through a legal system.[94]

Nuclear law contains key ideas which include law categories incorporated for practical reasons and conversion of internationally acknowledged principles of nuclear law into legal

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[92] Desart *Nuclear Law Bulletin* (2005) 215; and de Pompignan *Nuclear Law Bulletin* 49 (2007)

[93]Cameron *Journal of Environmental Law* (2007) 71–87

[94] McRae *The Compensation Convention (2012)*

expressions.[95]Simultaneously, subsidiary laws are needed for the implementation of the general laws. Kenya has adopted the general nuclear legislation to abide by the legal framework.[96]Domestic laws adapted by countries do also govern other types of harmful activities taking into account general law concepts. Nuclear legislation can be classified into three groups namely: accident procedures involving nuclear material, licensing procedures, control procedures.[97] Before the commissioning of the first NPP, a State must assess the availability of all the skills and knowledge existing locally and develop a strategy of ensuring a smooth flow of human resources in the nuclear industry.[98]

The SESA report for the nuclear power programme also provides for nuclear training fund which shall capacity build lead agencies as one of the policy recommendations. This will strengthen the capacity of officers in the sector. The occurrence of nuclear accidents cannot be completely eliminated even in circumstances where the highest level of protection has been attained. Nuclear legislation have to provide legal mechanisms to compensate for nuclear harm, which legislation must take into consideration the trans-boundary and inter-generational nature of nuclear damage.[99] The characteristics of safety and the environment requires governments to consider trans-boundary consequences through integration of policies and plans to ease the dangers associated with nuclear

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[95] German Act on the Peaceful Utilization of Atomic Energy and the Protection against its Hazards, as amended in 2002, Sections 3 and 4.

[96] IAEA *Milestones in The Development of A National infrastructure For Nuclear Power* Nuclear Energy Series No. NG-G-3.1 (2007).

[97] L. Rockwood '*Legal Instruments related to Application of Safeguards* presented at the IAEA/OPANAL seminar, Kingston, Jamaica' (1996) <http://www.opanal.org/Articles/Jamaica/jam-Rockwood.htm>.

[98] Sultan M., 'The International Safeguards System and Methods Applied at National and Regional Levels' (1998) 83, 85 Egyptian Atomic Energy Institution

[99]Cameron *Journal of Environmental Law (*2007)

not only to the nation or world population but to future generations too.[100] Secondly, the usage of nuclear material jeopardises not only the nation using it but the entire region thus disregarding national boundary. International cooperation is needed when dealing with illegal handling of nuclear material and nuclear explosive.[101] Most of the principles highlighted above originate from international treaties and conventions concerning the peaceful uses of nuclear power.[102] After ratification of a convention, the principles must be included in national legislation.[103] The safety principles and other universal principles such as the sustainable development principle and international cooperation principle come about within the context of developing environmental law and are based on legally non-binding instruments such as the Rio Declaration.[104]

Certain principles of nuclear law have certainly been approved by *opinio juris,* but the component of repeated state practice is more difficult to establish.[105] The inclusion of major concepts in nuclear law may result from consideration of international nuclear law instruments including non-binding ones, on issues of mutual universal concern. International nuclear legal framework of the IAEA expresses the major concepts of international nuclear law. OECD-NEA while defining regulatory effectiveness postulated by the IAEA, advanced the concept that a nuclear regulator is

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[100]El Baradei ea *The International Law of Nuclear Energy* 16

[101] Blix *Nordic Journal of International Law Vol.*58 (1989) 238

[102] El Baradei ea *The International Law of Nuclear Energy* 16

[103]Blix *Nordic Journal of International Law Vol* 58 (1989) 23

[104]These include non-proliferation, physical protection and nuclear liability. The origins of these principles will be discussed below.

[105]See article 18 of the *Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management*, 1997

considered constructive when it satisfies the following conditions.[106] Safeguards that a tolerable extent of security is sustained by the regulator (which is, the institutions managing NPP); maintains a high competency level; ensures that degradation of safety does not occur and encourage safety advancements; executes its regulatory purposes in a timely and low-priced manner at the same time in a way that provides confidence of operating entities, the public, and the government; and endeavours to continuously improve in its performance.[107]

2.3.2 The Constitution of Kenya, 2010

The Constitution of Kenya elaborates on various aspects that touch on nuclear technology. Article 10 provides for values and principles of governance which includes democracy and participation of the people, and sustainable development. These are principles that will ensure that the people are involved in the legislative process and, at the same time, siting since the community around the area that NPP will be constructed will have to accept the project and give out the land. In *Machakos Petition no. 16 of 2018 Wilfred Manthi Musyoka V. County Assembly of Machakos & Others Justice* Odunga stated that to afford the unrealistic public time to air their views would defeat the spirit of Article 10 of the Constitution of Kenya, 2010. This demonstrates how Article 10 is held with solemnity by the Courts and participation of the people is key in anything that affects them. The Government of Kenya has the duty to ensure that nuclear activities within its control do not cause damage to the environment or other Countries even as they enjoy the freedom

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[106] OECD-NEA *Improving Nucvflear Regulatory Effectiveness* (2003). <http://www.oecdnea.org/science/docs/pubs/nea5188-research-needs.pdf> accessed 20 February 2019

[107] Ibid

to exploit it. Such exploitation must be done equitably with considerations for the development and environmental needs of the present and future generations.

Article 35 provides access to information therefore, the Government should ensure that all nuclear information is accessible to the people of Kenya and should provide the information when requested. This encourages transparency and accountability since the public can access information of what the government is doing and intends to do; therefore will be able to understand the nuclear energy issues. Article 42 provides the right to a clean and healthy environment, which nuclear seeks to do since it is a clean source of energy. At the same time, nuclear activities should be done in a way that it will not harm the people and the environment. In *Mombasa ELC Petition No. 1 of 2016* (the famous Owino Uhuru lead poisoning Case), Lady Justice Anne Omolo stated that the petitioners' right to a clean and healthy environment according to Article 42 of the Constitution, right to clean and safe water under Article 43 and right to life provided in Article 26 were violated and awarded the petitioners a sum of 1.3 Billion. This case highlights how environmental issues should be taken seriously. Article 69 obligates the Government to ensure that processes and actions that are likely to jeopardise the environment. The Constitution has provisions that give persons the *locus standi* to go to court in case their environmental and health rights are violated in the course of producing nuclear energy.

2.3.3 The Energy Act, 2019

This law establishes the Nuclear Power and Energy Act, 2019, which was formerly KNEB. This is the institution mandated to promote/fast-track the development of nuclear energy in Kenya. This includes all matters that will lead to the usage/generation of nuclear power in Kenya. From ensuring that there is legislation to siting to public participation and awareness. The Act basically

creates the institution as far as nuclear energy is concerned. This Act recognizes that nuclear energy will be produced in Kenya, thus establishing the Agency that will fast-track the erection of nuclear power plants in Kenya. However, the Kenya Nuclear Regulatory Authority has the mandate to ensure that nuclear is used in Kenya in a secure, safe, and peaceful manner. This insinuates that the two institutions will have to collaborate to ensure that nuclear energy is produced according to the international standards set by IAEA.

2.3.4 The Nuclear Regulatory Act, 2019

This is the regulatory law in Kenya. It establishes the Kenya Nuclear Regulatory Authority that will ensure that nuclear science and technology in Kenya is used in a peaceful and safe manner. However, there are some gaps in this law.

First, Section 26 of the Act provides that

"a person aggrieved by the decision of the Authority under this Part shall have the right to apply to the Authority for a review of the decision."

This part includes licensing/authorization of authorized persons to operate activities, inspections, and enforcement. The Act should have set up a tribunal composed of members from outside the authority in order for the authorized persons to have a fair hearing. The same authority that licenses, inspects, and enforces cannot be the same authority to conduct a review since there are chances of a bias during the review. Nuclear activities are sensitive issues that require experts and independence. Second, Section 65 of the Nuclear Regulatory Act, 2019, provides the duty to exercise reasonable care by a carrier during transportation. However, there are no standards set to approve a carrier in order to ensure that nuclear consignment is safely transported. There will be a need for regulations to follow to ensure safety during transportation.

Third, the Act does not include Civil Liability by Nuclear Damage/Compensation Principle. The Act has not taken care of compensation or financial protection against damage. In case an accident occurs, the persons who incur damage should be compensated. There should also be compensation for deaths. Fourth, the Act establishes only one institution that deals with all components of nuclear power. It would be prudent to have other institutions deal with the different components like radioactive waste management and another to deal with the safety and security of nuclear plants as done in countries with nuclear energy production. Fifth, the aspect of non-proliferation of nuclear weapons has not been elaborately dealt with. Prohibition and suppression of any nuclear weapon activity should expressly be dealt with in law.

2.3.5 The Environmental Management and Co-ordination Act, 1999

This law provides for Strategic Environmental Assessment, Environmental Impact Assessment, Environmental Audit, and Monitoring. There are standards and limits set for effluent waste; therefore, nuclear activities will have to be kept in check. There was a proposal during the public participation of the Nuclear Regulatory Bill, 2018, to have someone from NEMA as a member of the Kenya Nuclear Regulatory Authority but it was not accepted since the Act does not have it. This would have enriched the board with practical environmental expertise. EMCA has environmental aspects that will be affected by nuclear energy production; there is a need for NEMA employees to be capacitated on nuclear matters so that they are known to provide the expertise needed.

2.4 Identified Gaps

The literature identified gaps related to the objectives of the study as follows.

i. To Assess the Role of Nuclear Energy in the Fulfillment of Electricity Security For Economic Growth

Challenges are facing Kenya's electricity sector, which includes reliability, availability, and affordability. It is normal to have power outages in Kenya. At the same time, the majority of the people living within do not have access to electricity. Some cannot access electricity due to its expensive nature. The current energy mix, therefore, is not capable of providing the base-load needed for economic growth. If nuclear energy is connected to the grid, it will provide that base-load and, at the same time, aid in combating climate change due to its clean nature. It is also affordable since it is said that electricity will cost three times less than the current cost. This relates to the statement of the problem since it explains that there is a need to have a source of electricity that will enable the country to grow economically, which impacts the social, environmental, political, technological, and legal well-being of the people. The technology used in industries/manufacturing may be current, thus positively impacting the environment, improving the quality of life, and legal implications.

ii. To evaluate the Regulatory Requirements of Nuclear Power Plant Sites in Kenya

Some issues concern regulatory requirements for siting. The Nuclear Power and Energy Agency has been given the mandate to deal with the siting. There are international guidelines by IAEA discussed in this Chapter that Kenya has not adopted but needs to be considered. Siting is an important aspect that needs to meet international requirements for NPP construction to guarantee the suitability which does not cause harm to the people and environment and at the same time escalating expenses. It is required that States that seek to produce nuclear electricity ensure that

the legal framework and regulatory competence are robust to enable safe production. The Nuclear Regulatory Act, 2019, only provides for site evaluation. The siting process, which includes site survey and site selection, has not been included in the law, which is equally essential for a desirable outcome. These guidelines or regulations, as the case may be, need to be drafted and published. The people need to be involved during the process. This relates to the problem statement that recognizes the IAEA standards that the Government needs to comply with.

iii. To Assess the Gaps in the Existing Legislative and Institutional Framework for Nuclear Energy Generation in Kenya

Another important gap is the legislative and institutional framework needed for Kenya's secure, safe, and peaceful use of nuclear electricity generation. There is only one institution established (Kenya Nuclear Regulatory Authority) to deal with the regulatory aspects, including licensing, radioactive waste management, safety, and security. This poses a risk of lacking a watchdog to ensure that rules and procedures are adhered to. The Government needs to put in place policies, regulations, and standards to protect and confront the consequences of nuclear waste. Licensing requirements need to be outlined, including qualification of the workforce for the operators to know before applying for a license. If a nuclear accident occurs, compensation needs to be dealt with in legislation to ensure that international standards properly address the compensation principle.

The accession of the Convention on Early Notification of a Nuclear Accident (the Early Notification Convention), the Convention on Assistance in the Case of a Nuclear Accident or Radiological Emergency (the Assistance Convention), the Convention on Nuclear Safety (‘the

CNS') and the Joint Convention on the Safety of Spent Fuel Management and on the Safety of Radioactive Waste Management is important. These are legal instruments that govern the nuclear energy sector of utmost importance, as discussed within the chapter. These instruments will also inform some of our laws, given that the international requirement is that they are also domesticated. In all the above public participation needs to be broken down into a way that the common citizen will understand. Documents need to be converted to Kiswahili for those who cannot understand English and those who cannot read; forums/ sensitization needs to be conducted in a language they know, given the unique nature of nuclear electricity production. This relates to the statement of the problem that seeks to examine the legislative and institutional framework challenges.

CHAPTER THREE: RESEARCH METHODOLOGY AND DESIGN

3.1 Introduction

This chapter describes the research methodology used in this research. It presents the research design, study area, sample size, sampling procedure and techniques used to select respondents, methods used to collect data research instruments, and data analysis techniques.

3.2 Research Design

Qualitative research is characterized by a non-random collection of data sources. Which means that the researcher will purposefully apply the sampling. Persons and items are selected due to the fact that there is possibility to get the greatest data about the topic[1] or based on their unique characteristics, experiences, attitudes, or perceptions.[2]The research adopted both quantitative and qualitative methods which included sampling, research instruments used, data collection, data analysis, interpretation, and reporting in order to address research objectives.

Purposive sampling approach is defined as a method in which associates of a sample are selected with an objective to represent a locality or category in relation to the criteria.[3] The study adopted purposive sampling and two Ministries which are the Ministry of Energy and Petroleum and the Ministry of Environment and Forestry were involved in providing data. There are also institutions in the electricity generation sector that have information which included: Nuclear Power and Energy Agency, EPRA, NEMA, the National Council for Occupational Health & Safety,

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[1] Leedy P.D. and Ormrod J.E, *Practical Research Planning and Design* (2005)
[2] Cooper D.R & Schindler, P.S *Business Research Methods* (2006) 9th Edition
[3] Ritchie J., Lewis J. & Elam G., 'Qualitative Research Practice: A guide for Social Science Students and Researchers' (2003) 77-108

KETRACO, KPLC, Kengen, County Assembly of Mombasa and REA. The institutions were selected due to the sectors they operate in; energy, environment, and safety. Technical officers, field operations officers, compliance and enforcement officers and legal officers were purposefully selected as participants to give the researcher the knowledge needed to understand nuclear electricity generation. Members of the County Assembly of Mombasa also participated. The institutions and officers chosen in this study had data and experience concerning assessing the role of nuclear energy in the fulfilment of electricity security for economic growth in Kenya, regulatory requirements of nuclear power plant sites, and assessing the gaps in the existing legislative and institutional framework for nuclear energy generation in Kenya.

The researcher's interview guide was the instrument used for collecting data on the respondent's experience, understanding and opinion on the assessment of nuclear energy as a source of electricity generation in Kenya: legal and institutional perspectives. The study targeted officers in institutions from the energy, environment and safety sector given that they have knowledge and experience in nuclear energy. Members of the County Assembly of Mombasa were also interviewed.

3.3 Target Population

This group which is also known as theoretical population represents the total population for which any research intends to assess.[4]The study targeted officers in institutions from the energy and environment sector. Members of the County Assembly of Mombasa were also interviewed.

[4] J. Whaley, 'Understanding Target Population in Research' <https://www.ovationmr.com/target-population-in-research/> accessed 01 November 2020

3.4 Research Instruments

The research instruments used to collect data were questionnaires and supplementary questionnaires. The questionnaires had both open-ended and closed-ended questions. This was the best way to obtain information on nuclear energy due to its complexity. Some were delivered in person, while others were sent by email.

3.5 Data Collection Techniques

3.5.1 Primary data

Primary data collection was done through the research instruments, which were questionnaires, supplementary questionnaires, and key informant interviews. The data was collected between July and October 2017, September to October 2020 and September to October 2021. The tables below provides information on those who participated in the study, their numbers and the tools used to collect data from them.

Table 1 Tools used to collect data

No.	Organisation	Interview guides
1.	NuPEA	7
2.	EPRA	6
3.	NEMA	8
4.	National Council for Occupational Health and Safety	1
5.	KETRACO	2
6.	KPLC	3

7.	Kengen	1
8.	County Assembly of Mombasa	6
9.	REA	1
10.	Ministry of Energy	4
11.	Ministry of Environment	2

Table 2 Key Informant Interviews

No.	Sector	Organization	No. of interviews
1.	Energy	NuPEA	3
2.	Energy	Ministry of Energy	1

3.5.2 Secondary data

The study involved a desk literature review that was analysed from different sources in order to find information. Secondary data sources included books, articles, journals, reports, magazines, and online portals.

3.6 Data Analysis

Patton (1987) states that data is condensed through summarization and categorization during data analysis, organized, and themes are recognized and linked.[5] Descriptive statistics was used to analyse the data which was done through content analysis thereafter classified into similar themes and topics. When analysing qualitative data reading of many transcripts is involved, looking for

[5] Barbara Kawulich, 'Data Analysis Techniques in Qualitative Research' (2006)

similarities or dissimilarities, and afterward finding themes and developing categories.[6] The data was collected through questionnaires and key informants' interviews were subjected to content analysis and narrative analysis. The data was coded by setting forth characterization of words, phrases, and paragraphs which was then used to create themes and concepts.

Excel was used to store, analyse and report the data that was collected. Presentation of the data analysed was done in tables, charts, and continuous prose.

3.7 Interpretation and Reporting

An integrated explanation is built through ideas and themes found, which should then be interpreted in the context of the literature and the theories presented in your theoretical framework.[7] This process will allow you to emerge with some overarching themes that can help tie the individual pieces of your data together.[8] The interpretation and reporting of the study were formulated into articles. In some instances, direct quotation was used, considering the objectives and theoretical framework of the study.

3.8 Ethical Considerations

The University of Nairobi provided the authority for the research to be conducted. Further, the researcher was authorized by County Assembly of Mombasa to research within the institution, Appendix 3. Consent was obtained from the respondents and the issue of confidentiality was

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[6] Wong L.P, 'Data Analysis in Qualitative Research: A Brief Research in Using Nvivo' (2008) 14-20 published in Malaysian Fam Physician https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4267019/#:~:text=Analysing%20qualitative%20data%20entails%20reading,coloured%20pens%20to%20categorise%20data.> accessed 30 January 2021

[7] Rubin, H., & Rubin, I. 'Qualitative Interviewing: The Art of hearing Data' (1995)Thousand Oaks, CA: Sage.

[8] Ibid

well explained to them. The researcher assured the respondents that the information provided would strictly be used for purposes of the research.

CHAPTER FOUR: RESULTS AND DISCUSSION

4.1 Results and findings

This chapter deals with the research findings, data analysis of results, and discussions details the results obtained during the data analysis of the responses received from the questionnaires and discussions with the respondents.

4.2 Demographic Characteristics of the Respondents

4.2.1 Gender of the Respondents

The study showed that 62% of the respondents were male, while 38% were female. Figure 4 shows the results

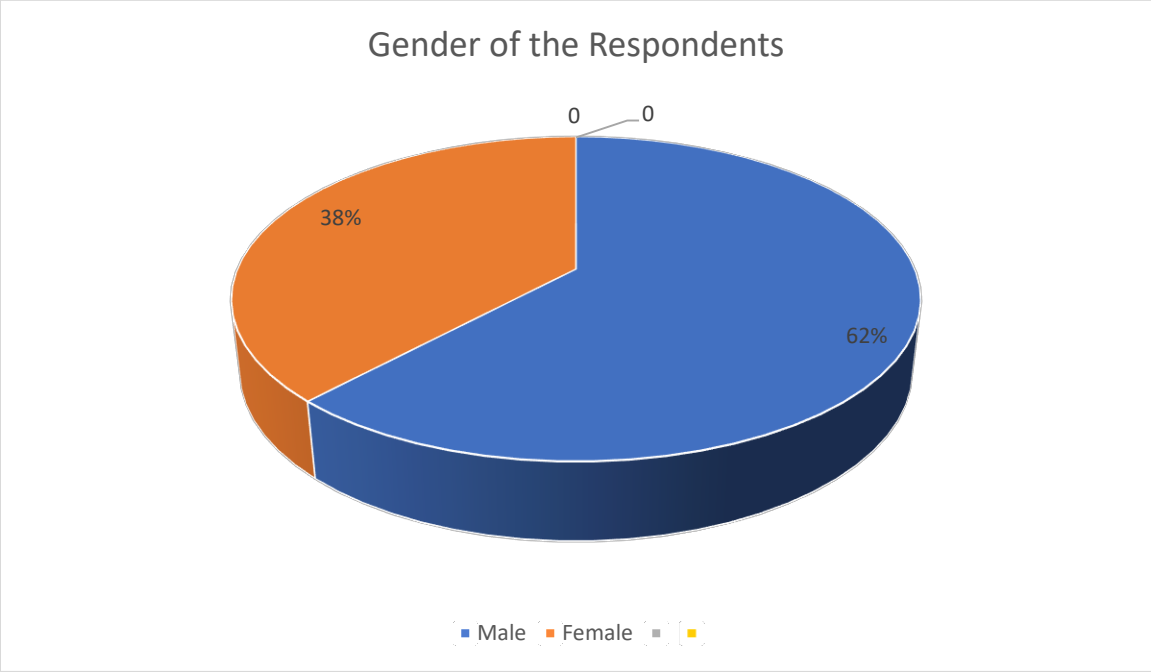

Figure 2 Gender of the respondents

4.2.2 Age

From the study majority of the respondents were between 30-39 years which represents 47%.

Table 3 below shows the summary of the findings.

Table 3 Age of respondents

Age Group	Frequency	Percentage
20-29	7	17
30-39	20	47
40-49	9	22
50-59	5	14

4.2.3 Duration of working in the Institution

The study showed that most of the respondents (51%) had worked in their respective institution for 5-10 years, as indicated below.

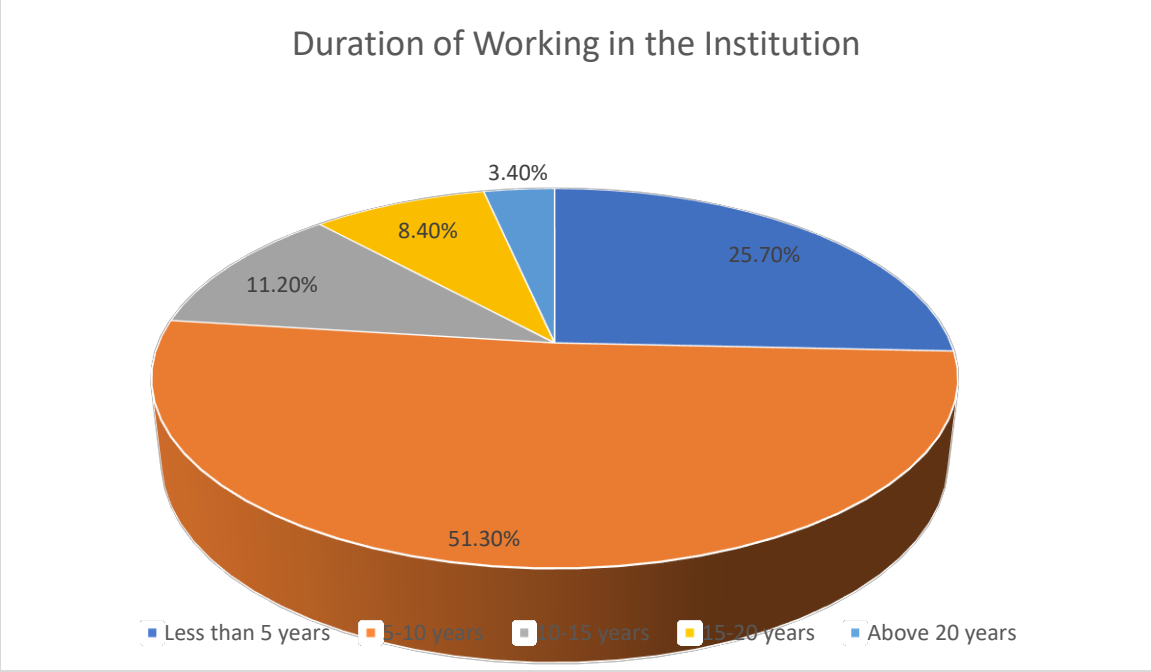

Figure 3 Duration of working in the institution

4.3 Role of Nuclear Energy in the Fulfillment of Energy Security in Kenya

Majority of the respondents (80%) were of the opinion that nuclear energy is a good option for usage in Kenya in order to achieve energy security. Those who agreed, confirmed that nuclear energy is clean and secure and does not leave carbon footprints, 20 %, offers reliable, cheap, and reasonable alternative power in the long term for both rural and urban areas of Kenya, 40%, suits the characteristics of a base-load, and if properly done, can offer higher energy capacity 20%. Those who did not agree argued that nuclear energy is radioactive 60%, hazardous and difficult to dispose the waste, 40% and therefore not safe for consumption in the country and they quoted the Fukushima and Chernobyl tragedy. They also decried Kenya's competence in having relevant technological know-how.

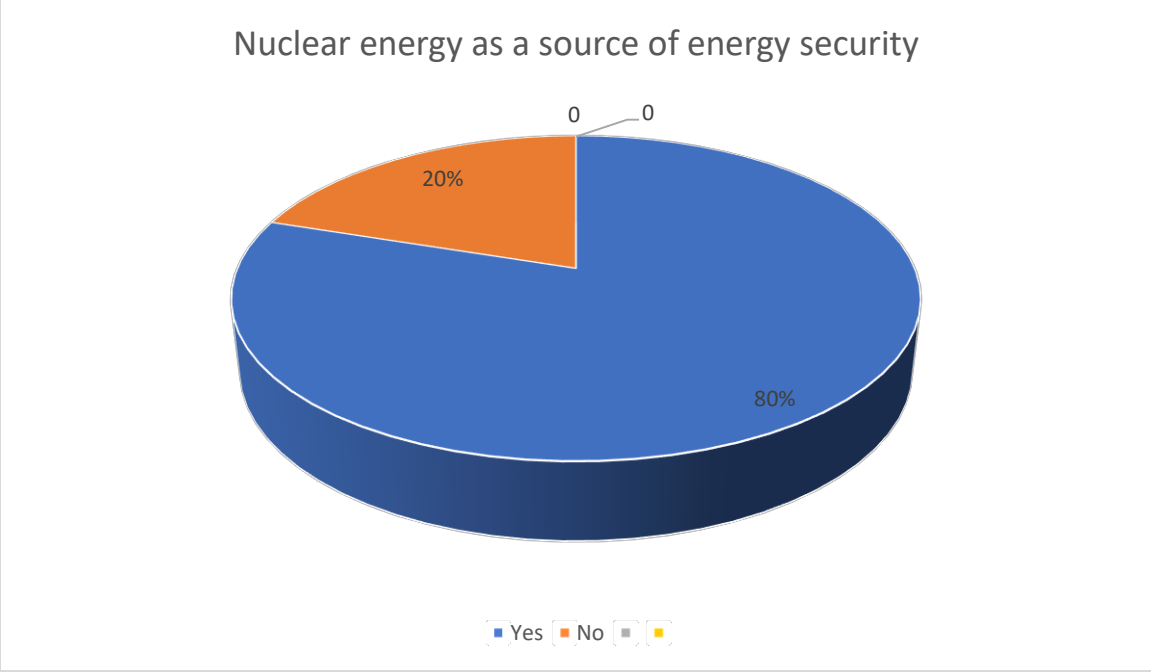

Figure 4 Nuclear energy as a source of energy security

4.4 Cost and Affordability of Nuclear Energy

The study showed that most of the respondents (60%) stated the cost would be lower than the current rate. In comparison, 40% showed it would be higher. To them, the cost factor was crucial, especially the high cost of the infrastructure taken to build it. The capital-intensive venture includes the high cost to meet the requirements of regulatory and international oversight bodies. While those who stated that the price would be lower mentioned the long-term effect that would result in reliable, efficient and cheaper power after all the initial costs and lower the overall cost due to economics of scale. There was also an dimension of the cost in regard to the social impact the NPP could cause. An MCA stated " people may have to move from their home which makes it difficult"

4.5 Environmental Challenges of Using Nuclear Energy

The study showed that the majority of the respondents (65%) opined that the greatest challenge to nuclear power production in Kenya is radioactive waste management. They particularly pointed to the lack of a more sustainable alternative to managing waste other than containment. 35% were of the view that the legal framework is lacking in details concerning managing nuclear waste.

Table 4 Environmental challenges of using nuclear energy

Challenge	**Percentage**
Radioactive waste management	65
Legal framework lacking in details with regard to managing nuclear waste	35

4.6 Discussion

4.6.1 The Role of Nuclear Energy in the Fulfillment of Energy Security for Economic Growth in Kenya

The study sought to determine the role of nuclear energy in the fulfillment of energy security for economic growth in Kenya. This section presents an analysis of responses given to pertinent questions asked to get the objectives of the study. The study results show that nuclear electricity generation in Kenya, just as it is in most economies, is mainly propelled by increased costs of fossil fuels, rising energy needs, inefficiencies in the energy mix, security of energy supply,

climate change, its cleanness as less carbon polluting than fossil fuels and raw material availability.[1]

The respondents emphasized that the intensity of usage of energy in Kenya is set to be on the increase based on the country's economic growth and development indicators. Therefore, nuclear electricity has been identified as a reliable and stable source of energy to stimulate manufacturing development and encourage economic growth, thus providing energy security. An enforcement officer stated, "Yes, nuclear energy is reliable and efficient as based on the current situation of inefficiency and costs."

Other studies also show that the prioritization of nuclear electricity persists because of reliability. Nuclear energy is in contrast with the alternative sources of energy; for instance, hydroelectric and photovoltaic pertain to environmental and safety issues, economic viability, and keeping the future frame of mind.[2] Nuclear energy's appeal sprawls in vast quantities, for example, its "cleanliness" (environment-friendly), enormous fuel energy density, and inexpensive transportation (1g of uranium can produce approximately 90,000 times more energy as 1g coal).[3]

Kenya's Vision 2030 identifies the socio-economic pillar can be enabled via energy. Where sustainable, affordable, and reliable energy for all citizens is identified as a major factor in accomplishing the country's vision. It is estimated that Kenya will need an estimated 16,000MW of electricity to support industrial growth that will have been achieved by then yet it is only able to generate 2,300 megawatts from various other energy sources even if all domestic energy

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[1] Leiserowitz, A., 'Climate change risk perception and policy preferences: The role of affect, imaginary and values' (2006).

[2]Ibid

[3]Ernst,W.G, 'Earth Systems: Processes and Issues' (2000) Cambridge University Press: Cambridge, UK

resources are optimized.[4]Data from the Energy and Petroleum Regulatory Authority show that electricity demand in Kenya is growing by 8 percent annually and it is anticipated to grow to 10 percent after 2020; thus, the current 2,300MW may not be enough to satisfy all Kenyans.

When asked if Kenya had the right generation mix to generate cheap electricity for industrialization and the Big 4 Agenda; the respondents stated that the inclusion of nuclear energy would likely stabilize and generate affordable electricity that will unlock the full potential of the Big 4 Agenda, thus enhance energy security and enhance opportunities in the electricity sector value chain.

According to some respondents, apart from the initial development cost, nuclear provides base-load capacity at the lowest tariff in a country while at the same time ensuring high reliability and availability. Nuclear power plant also has the flexibility to regulate generation compared to other power sources that are inflexible, making consumers pay additional costs for unused power, consequently a significant impact on economic activities, particularly those that are energy-intensive such as cement, steel, and pulp and paper production.

Lower energy prices resulting from using nuclear electricity will positively impact domestic wealth creation, the balance of payments, and employment creation since consumers will opt for locally manufactured goods and services that should be cheaper than imports. A technical officer indicated, “nuclear energy could be cheaper to consumers in the long run. Once the technology is adopted and implemented, I believe there would be a comparative advantage on economies of scale on production”.

[4] LCPDP 2017-2037

The anti-nuclear proponents argue that nuclear energy is radioactive, hazardous, and difficult to dispose of the radioactive waste.[5]This was the situation with some respondents who stated safety issues: examples quoted included the Fukushima and Chernobyl tragedy. They recognized that the risk and the resulting disaster might be quite high in the event of a calamity. They also questioned Kenya's competence on relevant technological know-how. A respondent stated, "Nuclear energy is radioactive and therefore not safe in case of an accident. Disposal of radioactive waste is also not particularly adequate, and Kenya lacks technology for the same".

But the Radiation Protection Board, as then was, allayed fears concerning the safety, security, and disposal of waste from nuclear energy. Although there is a need to consider an elaborate and sustainable approach to managing nuclear waste.

The high capital investment cost of a nuclear power plant and associated infrastructure was also a major concern. Nuclear electricity infrastructure is a capital-intensive venture. It is estimated that about Kenya Shillings 500 Billion is required to develop the infrastructure. This might only be achieved by engagement with the bilateral agreements and international Public-Private Partnerships, given the current status of debt the country has incurred. Although the current industrial infrastructure in Kenya does not house all the necessary technology and know-how and will not be of sufficiently high quality to support a nuclear power programme, countries in Asia and the Pacific have used bilateral agreements and contracts for the transfer of technology, thus

[5] Alexander Shlyakhter, Klaus Stadie and Richard Wilson, 'Constraints Limiting the Expansion of Nuclear Energy' <http://wilsonweb.physics.harvard.edu/publications/ppaper617.html> accessed 02 January 2019

developing their support industries participation in nuclear power programmes which has benefited local industries, as a result of their adopting more advanced production techniques.[6]

In Kenya, the cost of the first 10 units (kwh) of energy consumed costs Kshs.12 per unit, which previously cost Kshs. 2.50 per unit. The next 40 units cost Kshs. 15.80 per unit, which previously cost Kshs. 2.50 per unit. This is expensive given that a band that was charged at Kshs.100 is charged at Kshs. 632 from 2018,[7] while in India and China, the cost of a unit (kwh) is 8 USD cents, the cheapest in the world.[8]These two Countries use nuclear electricity.

4.6.1.1 Cost of establishing nuclear power plants in Kenya

NPPs are different given that they do not burn anything to create steam but instead split uranium atoms in a process called fission.[9] As a result, unlike other energy sources, they do not release carbon or pollutants like nitrate and sulfur oxides into the air.[10] Nuclear reactors are designed to sustain an ongoing chain reaction of fission; they are filled with a specially designed, solid uranium fuel and surrounded by water, which facilitates the process.[11] When the reactor starts, uranium

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[6] H.J., Laue, 'Nuclear Power and Technology Transfer' IAEA Bulletin Vol. 24 No. 4 <https://www.iaea.org/sites/default/files/24404781923.pdf> accessed 10 October 2018

[7] Joseph Sosi, '*New Kenya Power Tarriff Increases Cost of Electricity'* <https://www.kenyans.co.ke/news/31882-new-kenya-power-tariff-increases-cost-electricity> accessed 21 September 2018

[8]OVO Energy, 'Average electricity prices around the world' <https://www.ovoenergy.com/guides/energy-guides/average-electricity-prices-kwh.html> accessed 23 February 2019

[9] Nuclear Energy Institute *How a Nuclear Reactor Works* (2020) <https://www.nei.org/fundamentals/how-a-nuclear-reactor-works> accessed 23 September 2020

[10] Ibid

[11] *Supra* note 202

atoms will split, releasing neutrons and heat.[12] Those neutrons will hit other uranium atoms, causing them split and continue the process, generating more neutrons and more heat.[13]

Not every country can afford to use nuclear energy since it is a capital-intensive technology.[14]However, the cost of nuclear power plants varies from country to country. Plant construction depends on discount rates in every country; for example, the discount rate in the U.S.A is 12.5%, 8% in France, and 2-3% in Japan.[15] The variation in discount rate is one of the major factors determining the economic viability of nuclear power across the world. A 2015 study which involved 22 countries found that, at a discount rate of 10 percent, the median cost of both natural gas and coal was lower than nuclear energy, while at a discount rate of 3 percent, nuclear energy was the most economical option in all countries analysed.[16] This therefore means that if the Government of Kenya subsidizes capital costs, the cost of nuclear power may be lower and manageable. The cost of establishing a NPP was known by a majority of the respondents to be very expensive. Most of the respondents, 80%, found the cost of establishing nuclear power very expensive. They stated figures ranging from 500 million to 5 billion while others just used the word very expensive.

NuPEA is also in the course of creating major objectives and requirements to direct the nuclear power programme, which entails coming up with NPP ownership and financing, how industries

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[12] Ibid

[13] Ibid

[14] Daria Lurshina, Nikita Karpov et al., 'Why Nuclear Power Plants Cost so much and What Can be Done About it' *(*2020)

[15] Ibid

[16] Daria Lurshina, Nikita Karpov et al., 'Why Nuclear Power Plants Cost so much and What Can be Done About it' *(*2020)

are going to be involved, a nuclear fuel cycle and radioactive waste management. NuPEA has developed a draft Policy for Radioactive Waste Management which is a wrong precedence given that it is against the international standards on the independence of a regulator in legal and government infrastructure as accorded by IAEA, 2000.[17]Policies and regulatory structures are best put in place by an independent regulator to minimize the risk of security and safety compromise from the NPP operator, who shall be under the watch of the independent regulator.[18]

Kenya was listed among the nuclear energy newcomer countries that are going to benefit from infrastructure development, research, design, handling radioactive waste, operation of the plant amongst others from the Russian nuclear power company Rosatom through the IAEA.[19] Rosatom signed an agreement with the IAEA to provide a financial contribution of $1.8 million (about Sh185.51 million) and a financial contribution of up to $1.9 million (Sh195.81million) in kind in the next three years to the IAEA for infrastructure development.[20] There will be newcomer countries like Turkey, Belarus, Saudi Arabia, Nigeria, Egypt, Ghana, Tunisia, Uganda, and Tanzania. It is therefore envisaged that by 2027, Kenya may have the first nuclear power plant, with construction expected to start in 2024.[21]

Those who agreed, confirmed that nuclear energy is clean and secure and does not leave carbon footprints; 20% offers reliable, cheap and good alternative power in the long term for both rural

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[17] IAEA Series No. GS-R-1

[18] Nuclear Power and Energy Agency *Strategic Environmental and Social Assessment Report for Kenya's Nuclear Power Programme* (2020) 88

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[20] International Atomic Energy Agency *Rosatom Sign Agreement to Strengthen IAEA Nuclear Infrastructure Capacity Building* (2017) https://www.iaea.org/newscenter/pressreleases/iaea-rosatom-sign-agreement-to-strengthen-iaea-nuclear-infrastructure-capacity-building accessed 15 February 2019

[21] Reports/Signal *"Kenya to Setup Nuclear Power Plant in 2024"* < http://www.signalng.com/kenya-set-nuclear-power-plant-2024/> accessed 15 February 2019

and urban areas of Kenya, 40% suits the characteristics of a base-load and if properly done, can offer higher energy capacity. Those who did not agree argued that nuclear energy is radioactive, 20% hazardous, and difficult to dispose waste 27% and therefore not safe for consumption in the country. They quoted the Fukushima and Nagasaki tragedy. They also decried Kenya's competence in having relevant technological know-how.

It can be deduced that according to a majority of respondents, nuclear is a viable source of energy to power Kenya's forecasted industrial growth. It also emerged from the finding that nuclear energy is clean and offers reliable power. This is in line with the social, economic, and environmental pillars and sustainable development building blocks envisaged in the Kenya Vision 2030, aimed at developing Kenya into a middle-income economy by the year 2030, characterized by a vibrant yet green economy. It is, however, notable from the findings that the country needs to adequately invest in ensuring the safety of the environment with respect to radioactivity in nuclear production and disposal of radioactive waste.

In the area of cost and affordability of nuclear power, there were three groups that clearly came out. Those who converged around the point that it would be higher were 40% and to them, the cost factor was crucial especially the high cost of the infrastructure taken to build it, the capital-intensive venture that includes the high cost to meet the requirements of regulatory and international oversight bodies. In contrast, those who stated it would be lower at 60 % looked at the long-term effect, which would result in reliable, efficient and cheaper power after all the initial costs, as well as lowering the overall cost due to economies of scale.

It can be deduced from the foregoing findings that a majority of stakeholders in the Kenya nuclear energy sector are not agreeable on the anticipated cost of nuclear energy. This can be attributed to

the fact that nuclear energy has never been produced in the country and it is not certain to a majority of stakeholders as to whether the cost is expected to be high or low. It is envisaged in Vision 2030 that Kenya is set to increase its energy output to over 10,000 Megawatts. It is also envisaged that by the year 2027, Kenya will have its first nuclear power plant to start generating nuclear electricity to add to the energy grid. It is thus expected that the same will be made affordable and thus accessible to a majority of Kenyans.

The local property value may increase or decrease in response to the construction of a NPP depending on the perception of the individuals on health risk, noise controls, visual impacts, additional employment opportunities and other factors.[22] There is a social effect on movement of the people thereby affecting the population and their way of life and at the same time an economic effect of the government having to compensate those who had land within the area if the land belongs to the people but not the government. This impacts on the overall finances needed for the construction of a NPP thereby increasing the costs.

4.6.2 The Regulatory Requirements of Nuclear Power Plants Sites in Kenya

Although site identification has not been concluded, the KII informed that the complete site survey is ready. This is available in the draft SESA report, which analysed the Coastal region, the Lake Victoria Basin, and Lake Turkana Basin.

The study sought to evaluate the regulatory requirements for siting in Kenya. This section presents an analysis of literature review and responses given to pertinent questions asked to achieve this objective. Majority of the respondents (62%) were aware that there are regulatory requirements

[22] J.C., Weiss, B.B., Boehlert and R.E., Unsworth 'Assesssing the Costs and Benefits of Electricity Generation Using Alternative Energy on the Outer Continental Shelf Final Report' (2007) 31

for siting but they are not well conversant with them. A respondent stated, "IAEA issues regulations, but I have not read them to know the contents."

The IAEA Safety requirements provide for a criterion to ensure safety in site evaluation.[23]The purpose of the publication is to institute the requirements for the essentials of a site assessment for a nuclear connection so as to describe entirely the site-specific conditions related to the security of the nuclear installation.[24] The siting procedure for a nuclear installation comprises an examination of a big area to choose one or more candidate sites, thereafter an assessment of those sites. The publication deals with evaluating those site-related factors that have to be taken into account to ensure that the site installation combination does not constitute an undesirable hazard to individuals, the population, or the surrounding over the lifetime of the installation.[25] Population density and distribution are some of the considerations made, given that it could also influence emergency response. The safety requirements also help in providing the information needed during EIA for radiological hazards.

The expected radiological effects in operating states and in calamity conditions in each proposed site, including effects that warrant exigency response actions, must be assessed with contemplation of uses of land and water, population distribution, dietary habits and the radiological effects of any

[23] International Atomic Energy Agency, 'Site Evaluation for Nuclear Installations' IAEA Safety Standards Series No. NS-R-3 (Rev 1) (2016) <https://www.pub.iaea.org/MTCD/Publications/PDF/Pub1709web-84170892.pdf> accessed 20 September 2018

[24] Ibid

[25] *Supra* note 213

discharges radioactive substance in the area.[26]Others are air temperatures and humidity, water temperatures and available flow of water and minimum water levels.

The location of a nuclear plant is important as well as emotive. The study sought to know whether Kenya has selected areas likely to be used for the erection of a nuclear plant. According to a majority of the respondents, 68% put it that a considerable amount of effort has been made to find a location for the nuclear power plant. They, however, felt that public participation had not been done to ensure that the residents in the various areas were engaged and involved in the process to make it acceptable in their neighbourhoods, given that Article 10 of the Constitution of Kenya, 2010 provides for the participation of the people in undertaking such an endeavour. A number of the respondents, 40%, said that Kenya was in the process of auditing the capacity of its grid to accommodate nuclear power and locate a site for a nuclear power plant. A legal officer stated, "Recently Kenya audited the capacity of its grid to accommodate nuclear power. Complementary issues like the availability of demand to warrant the inclusion of nuclear needs to be carried out". It is observed that regional public participation on the Nuclear Regulatory Bill, 2018, was done in 2019 by the National Assembly.

The study probed in this regard to determine whether or not the selection of the location complies with physical planning and development control rules relating to locating waste handling facilities. It was found in this regard that the same will become apparent once the locations have been firmed up, subject to detailed feasibility studies. The study further sought to find out whether there has been a Strategic Environmental Assessment (SEA) for the generation of sustainable nuclear energy

[26] Ibid

in Kenya. It was established in this regard that a SEA study was conducted to justify the need for a nuclear power plant. It was conducted to identify potential, social, environmental, safety and health hazards from nuclear generation in the Kenyan context.

4.6.3 The Gaps in Existing Legislative and Institutional Framework for Nuclear Energy Generation in Kenya

The study shows that lead agencies EPRA, NuPEA, Ministry of Energy, NEMA, amongst others, are significantly aware of and versed with the need of the country to have a legal and institutional framework to be able to develop the sector. However, the Nuclear Regulatory Act, 2019, has gaps that have been discussed within the study. The study sought to establish whether the nuclear energy legal framework provides for policy-approach alternatives with regard to sustainable nuclear energy generation and waste disposal. 50% of the respondents indicated that the legal framework offers policy-approach options for sustainable energy generation and waste disposal. In comparison, the other 50% indicated otherwise. A respondent stated, “Yes. We have alternatives which have been considered, and the best alternative will apply if the environmental issues won’t be satisfied”. Two policy alternatives were established in this regard, including a cessation of nuclear fuel cycle policy and strategy and the radioactive waste management policy and strategy. The study finally sought to determine whether or not the legal framework guards against access to nuclear energy or waste by rogues or terrorists who may use it to make weapons of mass destruction like atomic bombs. 36% of the respondents believe that the legal framework guards against access to nuclear energy or waste by rogues or terrorists who may use it to make weapons of mass destruction like atomic bombs, while 64% opine otherwise. A respondent stated, “We have a chapter on Nuclear Safeguard and Nuclear security in the Nuclear Regulatory Bill with very

prohibitive provision on such attempts." Respondents also agreed that the same calls for a multi-stakeholders approach, including law enforcement.

Kenya adopted the IAEA milestone approach, and the development of Kenya's nuclear infrastructure is designed to meet the following objectives i) Comprehensively recognize and identify the State's duties and responsibilities relating to the introduction of nuclear energy ii)establish and prepare the national structure required to initiate the erection of a NPP and iii) establish the needed skills and competencies to be capable to govern and operate a NPP with safety, security and economics taken into consideration over its lifetime.[27]

The major role of a legal and regulatory framework in a NPP has been spearheaded by the Nuclear Power and Energy Agency which engaged LSK during the 2018 annual Law Society of Kenya (LSK) Conference, held in August 2018. Under the theme: The Rule of Law and Contested Constitutionalism in Post 2010 Kenya: Promises, Progress, Pitfalls, and Prospects.[28] The legal profession has the onerous task of formulating the legal and regulatory framework for Kenya's nuclear power program as per the International Atomic Energy Agency's guidelines. This is to lead the public discourse on nuclear law.

The Nuclear Regulatory Act, 2019 establishes Kenya Nuclear Regulatory Authority to provide oversight and enforce stipulated standards as per the Act and international best practices in the nuclear industry. In a nutshell, it exercises regulatory control over nuclear affairs in Kenya.

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[27] Kenya Engineer *Roadmap for Kenya's Nuclear Power* (2017) <https://www.kenyaengineer.co.ke/roadmap-for-kenya-s-nuclear-power-programme/> accessed 23 February 2019

[28] KNEB Sensitize Lawyers on Nuclear Energy at the Annual LSK Conference https://www.nuclear.co.ke/index.php/en/information-center/press-release/news/80-kneb-sensitize-lawyers-on-nuclear-energy-at-the-annual-law-society-of-kenya-conference accessed 19February2019

However, Civil Liability and Non-proliferation of nuclear weapons are some of the aspects that have been left out in the Act. Having an umbrella institution to deal with all nuclear energy aspects is a bit generalized. Nuclear energy production is technical, and some aspects need to be dealt with independently for better management of power production. The Act has repealed the Radiation Protection Act, 1985. Although there are various statutes and regulations in Kenya, they do not adequately address certain aspects like the proliferation of nuclear weapons, which exposes Kenya to legal muddle; the international siting standards are also missing, thereby necessitating drafting of the more legal framework that specifically addresses the concerns in nuclear energy production. The energy mix available currently is unreliable and expensive and needs nuclear energy to boost it.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter deals the conclusions and recommendations which are based on the objectives of the research.

5.2 Conclusions of the Study

5.2.1 The Role of Nuclear Energy in the fulfillment of electricity security for economic growth in Kenya

The findings of the study established that nuclear energy can be used for economic growth in Kenya since it has a base-load that creates energy security. Energy security is what is needed in order for industries to grow in Kenya. The projected demand for electricity in the future years will be high; thus, the supply has to be expanded to meet this demand. The study established that the current energy mix needs a booster to meet this demand and nuclear power is required to provide this given that it is reliable since it is capable of producing maximum energy during the year as compared to other sources of energy. It is also clean and can help combat climate change.

5.2.2 The Regulatory Requirements of Nuclear Power Plants Sites in Kenya

There are no regulations or guidelines to govern the selection of sites for NPP currently. The IAEA has guidelines that provide recommendations and direction on instituting a process which is systematic for site survey and site selection for preferred candidate sites, from which one can be chosen for the erection and operation of a nuclear plant. The findings established that the Nuclear Power and Energy Agency is currently developing ToR for site characterization. It was also established that it is mandatory to involve stakeholders and coordination of both national and

county government is needed in order to achieve acceptable siting.

5.2.3 The Gaps in the existing Legislative and Institutional Framework for Nuclear Energy Generation in Kenya

The Nuclear Regulatory Act, 2019, provides for the regulation of nuclear energy in Kenya. It established the Kenya Nuclear Regulatory Authority, which is mandated to regulate nuclear energy in Kenya. There is also the Energy Act, 2019, which establishes the Nuclear Power and Energy Agency. However, it was demonstrated that they have gaps which may need further legislative and institutional development in order to use nuclear energy in a safe, secure, and peaceful manner.

5.3 Recommendations

The following are the recommendations of the study:

1. Further Enactment of Nuclear Energy Legislation

The two recent statutes enacted to deal with nuclear energy are the Energy Act, 2019, and The Nuclear Regulatory Act, 2019 that deals with all aspects of nuclear energy. Nuclear energy matters are technical, and some aspects should be dealt with independently. The study recommends that nuclear waste management, nuclear safety, and nuclear radioprotection be separated from the Nuclear Regulatory Act, 2019 so that there exists four statutes and Nuclear Regulatory Act, 2019 retains the licensing aspect only. Civil liability also needs to be included in the Nuclear Regulatory Act, 2019; thus an amendment to the Act should be done. NuPEA should spearhead this to ensure it is done by April 2022. The Kenya Nuclear Regulatory Authority should spearhead the enactment of Nuclear Waste Management, Nuclear Safety and Nuclear Radioprotection in conjunction with NuPEA and other stakeholders, which should be done by the end of 2023. This will create a safer

environment for work in the nuclear industry in Kenya. Further, siting regulations need to be drafted and passed to establish a systematic site survey and selection process for several preferred candidate sites. So far, the final SESA report provides candidate sites and their suitability. It also provides the criteria used to conclude. However, it would be prudent to have regulations in place for citizens to understand the steps taken to select a site and, at the same time, follow the best practices as laid out by IAEA. NuPEA should do this by April 2022.

2. Establish More Nuclear Energy Institutions

The Nuclear Regulatory Act, 2019 establishes one umbrella institution which is the Kenya Nuclear Regulatory Authority, mandated with all functions to do with nuclear in Kenya. However, it would be prudent to have different institutions deal with nuclear energy for specialization and it also creates the need for an institution to act as the other's watchdog. The study proposes the following institutions be established:

i. Nuclear Radio-protection Authority
ii. Nuclear Safety Authority
iii. Nuclear Radioactive Waste Authority

These are institutions created by statutes; therefore, the Kenya Nuclear Regulatory Authority and NuPEA should lead in drafting the Bills after which forwarded to the National Assembly for enactment by the end of 2023.

3. Technical and Capacity Development in the Nuclear Energy Sector

During the research it was noted that some of the staff that work in the various institutions did not have knowledge or technical expertise on nuclear electricity production. There are technocrats needed to operate the nuclear plants like nuclear engineers, equipment operators, and nuclear

security officers amongst others. Kenya needs to build the capacity of those already in the industry by taking them to institutions offering the needed trainings. It is also important to have practical experience through exchange programmes with countries that operate the plants like the U.S.A and Japan. This is a continuous process from now to the time the NPP will be decommissioned.

4. Public Perception and Public Participation

a. The public generally perceives nuclear electricity as a dangerous source of energy. This perception is because most people do not understand the concepts of nuclear electricity production; for example, some think nuclear is dangerous due to the accidents it is capable of causing. However, the pros of nuclear electricity production seem to be unknown to them. There are also third-generation nuclear reactors that mitigate aspects of an accident, with the fourth generation underway. Access to information is key to public participation; therefore, the government should avail information before the participation forums. The study recommends that the government make arrangements to educate and add knowledge to the public through sensitization forum /public awareness programs to understand the concepts of nuclear electricity production.

b. The siting of a location to construct the nuclear power plant in Kenya is yet to be done. Article 10 and Article 69 of the Constitution of Kenya 2010 provides for the participation of the people in environmental matters; therefore, when the Government is conducting the allocation of a site, the study recommends that the communities around the area, together with those in the entire country be involved/ participate in the process to own the project and make it acceptable to them and know the pros and cons too. This may give the Government an easier time to complete the project. This process should commence immediately, given that the Government has already identified some locations under the SESA report. NuPEA is the right entity to spearhead this process.

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LIST OF APPENDICES

Appendix 1: Interview Guide

My name is Christine Mududa. I am a student at the University of Nairobi, Center for Advanced Studies in Environmental Law and Policy pursing a Masters of Arts in Environmental Law. I am Carrying out a research on "The assessment of nuclear energy as a source of electricity generation in Kenya: Legal and institutional perspectives". Tour consent to participate in this interview is required and once agreed, your consent to record is requested but you have the option to decline and you can write down your responses.

Thank you for taking your time to contribute to this research.

SECTION A: BACKGROUND INFORMATION

1. Name of institution: …….

2. Designation of respondent: …….

3. Gender: Male [ ] Female[ ]

4. Age:

5. Number of Years in the institution:

Less than 5 [ ] 5 – 10 [ ]

10 – 15 [ ] 15 – 20 [ ]

Over 20 years [ ]

6. Department: ……..

SECTION B: ROLE OF NUCLEAR ENERGY IN THE FULFILLMENT OF ACCESSIBLE AND EFFICIENT ENERGY SOURCES IN KENYA

7. Is nuclear energy a good alternative for usage in the rural and urban areas of Kenya?

Please elaborate?.....

……

……

8. How would you rate affordability of nuclear energy in Kenya? Will it be lower or higher?

Please explain.....

……

……

9. Compared to other sources of energy, how would you rate nuclear energy electricity production?

Please elaborate.....

……

……

10. What would be the cost of establishing a nuclear power plant in Kenya?

……

……

11. What are the environmental challenges of using nuclear energy production in Kenya?

……

……

SECTION C: GAPS IN THE EXISTING LEGISLATIVE AND INSTITUTIONAL FRAMEWORK FOR NUCLEAR ENERGY GENERATION IN KENYA

12. What legislation framework provides for nuclear energy generation in Kenya? Please elaborate.

……

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13. What regulations provide for nuclear energy in Kenya?

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14. What roles are the respective institutions charged with to play in nuclear energy generation in Kenya? Please elaborate.

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15. What capacity do the institutions have to handle their mandate with respect to nuclear energy generation in Kenya? Please elaborate.

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SECTION D: STRATEGIES FOR SUSTAINABLE NUCLEAR ENERGY GENERATION IN KENYA

16. Has Kenya audited its capacity to sustainably generate nuclear energy? Please elaborate.

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17. Has a location been identified for the construction and commissioning of the nuclear power plant?

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……

18. Does the selection of location comply with physical planning and development control rules relating to locating waste handling facilities? Please elaborate

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……

……

19. Has there been a Strategic Environmental Assessment (SEA) for generation of sustainable nuclear energy in Kenya? Please elaborate.

……

……

……

20. Does the nuclear energy legal framework provide for policy-approach alternatives with regard to sustainable nuclear energy generation and waste disposal? Please elaborate

……

……

……

21. Does the legal framework guard against access to nuclear energy or waste by rogues or terrorists who may use it to make weapons of mass destruction like atomic bombs? Please elaborate

……

……

……

Appendix 2: Supplementary Interview Guide

My name is Christine Mududa. I am a student at the University of Nairobi, Center for Advanced Studies in Environmental Law and Policy pursing a Masters of Arts in Environmental Law. I am Carrying out a research on "The assessment of nuclear energy as a source of electricity generation in Kenya: Legal and institutional perspectives". Tour consent to participate in this interview is required and once agreed, your consent to record is requested but you have the option to decline and you can write down your responses.

Thank you for taking your time to contribute to this research.

SECTION A: BACKGROUND INFORMATION

1. Name of institution: …….

2. Designation of respondent: …….

3. Gender: Male[ ] Female [ ]

4. Age:

5. Number of Years in the institution:

Less than 5 [ ] 5 – 10 [ ]

10 – 15 [ ] 15 – 20 [ ]

Over 20 years [ ]

6. Department: ……..

SECTION B: ROLE OF NUCLEAR ENERGY IN THE FULFILLMENT OF ELECTRICITY SECURITY IN KENYA

7. Is nuclear energy a reliable source of energy?

Please elaborate?.....

……

……

8. Does nuclear energy have any environmental impact?

Please explain.....

……

……

9. Is Kenya experiencing growth in energy consumption and demand?

Please elaborate.....

……

……

……

SECTION C: THE REQUIREMENTS FOR SITE SELECTION IN KENYA

10. What is the site selection process?

……

……

……

11. Are there any regulatory considerations for site selection process in Kenya? Please elaborate.

……

……

……

12. Has there been a Strategic Environmental Assessment (SEA) for generation of sustainable nuclear energy in Kenya? Please elaborate.

SECTION D: THE GAPS IN THE EXISTING LEGISLATIVE AND INSTITUTIONAL FRAMEWORK

13. Are there risks associated with generation of nuclear energy? Please state.

……

……

……

14. Can the existing laws and institutions cover the risks? Kindly explain

……

……

……

15. Does the nuclear energy legal framework provide for policy-approach alternatives with regard to sustainable nuclear energy generation and waste disposal? Please elaborate

……

……

……

SECTION E: THE LAWS AND INSTITUTIONS NEEDED FOR NUCLEAR ENERGY PRODUCTION IN KENYA

16. What are the laws and institutions needed for nuclear energy generation in Kenya?

…….....

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Appendix 3: Authorization to Conduct Research at The County Assembly of Mombasa

COUNTY ASSEMBLY OF MOMBASA

OFFICE OF THE COUNTY ASSEMBLY CLERK

Email: Countyassemblymombasa@gmail.com

P O Box 80438 – 80100
MOMBASA, Kenya

When replying please quote:

Ref: CAM/CAC/LM/VOL.V/212

15th October 2021

Ms Christine Mududa
University of Nairobi
251/79750/2012

RESEARCH AUTHORIZATION

The above matter refers.

This is to inform you that you have been authorized to carry out research on **"The Assessment of Nuclear Energy as a source of electricity generation in Kenya:Legal and Institutional Perspectives"**

The authorities concerned are therefore requested to give you maximum support so that this research is completed within schedule.

Salim Juma
CLERK
COUNTY ASSEMBLY OF MOMBASA