ROLE OF NUCLEAR ENERGY IN COMBATING CLIMATE CHANGE

Eng. Collins Gordon Juma, MBS Chief Executive Officer Nuclear Power and Energy Agency and Immediate Past IEK President; Email: jugoco3@gmail.com Phone: 0722525890

**Chesire Kipkemboi Edwin National Liaison Assistant Nuclear Power and Energy Agency Email: cedwin@nuclear.co.ke ; chesireedwin@gmail.com Phone: 0723696146*
*Corresponding Author

ABSTRACT

Access to energy is regarded as the basic requirement for economic growth. And yet 1.5 billion people in the world today don't have access to the basic form of energy, electricity [1]. . In order to ensure energy security, Kenya diversified the energy source that will ensure affordability, clean and reliable source of electricity to power the national development agenda. The drive towards the use of nuclear power in Kenya's electricity mix started in 2010 when the National Economic & Social Council (NESC) recommended its use to meet the growing electricity demand. In implementing the Kenya's nuclear power programme, Nuclear Power and Energy Agency (N*u*PEA) is following the International Atomic Energy Agency (IAEA) Milestone Approach [2]

Climate Change has become a subject of national, regional and international discussion. The effects are being felt currently. The Energy Sector has had a role in contributing to Climate Change in the whole world. There are many different electrical generation methods, each having advantages and disadvantages with respect to operational cost, environmental impact, and other factors. According to the Intergovernmental Panel on Climate Change (IPCC), the world emits approximately 27 Gigatonnes of CO2e from multiple sources with electrical production emitting 10 Gigatonnes, or approximately 37% of global emissions [20]. In addition, electricity demand is expected to increase by 43% over the next 20 years [3]

The complementary role of Nuclear energy, hydropower and renewables is key in ensuring a low carbon economy by 2050. It is stated that between the periods 1970-2013, this combination has helped in avoiding the emissions of about 163 Gt of CO2 emissions in total. Hydropower accounted for 53% (87Gt CO2) and Nuclear Power contributed 41% (66 Gt CO2) and other renewables saved 6 % (10Gt CO2) .[5]

Nuclear power has been considered to have the potential to meet the climate change challenge by providing electricity for domestic and for industrial processes, generated with almost zero greenhouse gas emissions. The potential role for Nuclear has also been cited in the Intergovernmental Panel on Climate Change (IPCC) Special Report on global warming of 1.5 celcius. [3]

Clean and sustainable energy is essential for Kenya's sustainable development and is considered one of the infrastructure enablers of the socio-economic pillar of Vision 2030. Besides the reliability and predictability that nuclear power offers in the electricity markets, it also has non-climatic environmental benefits and minimizes the impact on human health as it emits practically no local or regional air pollutants.

Key Words: Nuclear Energy; Climate Change; Green House Gasses

BACKGROUND

Access to energy is regarded as the basic requirement for economic growth. And yet 1.5 billion people in the world today don't have access to the basic form of energy, electricity [1]. Worldwide there are 443 nuclear power reactors in operation translating to 392,751MWe of total net installed capacity. Further there are 53 nuclear power reactors under construction equal to 56,270 MWe of total net installed capacity. In total there is 18,683 reactor- years of operation.

The drive towards the use of nuclear power in Kenya's electricity mix started in 2010 when the National Economic & Social Council (NESC) recommended its use to meet the growing electricity demand. In November 2010, the Government established Nuclear Electricity Project Committee (NEPC) to steer the nuclear energy generation programme. NEPC was later transformed to Kenya Nuclear Electricity Board (KNEB) vide Gazette Notice No. 131, Supplement 156 of 23rd November, 2012. The mandate of KNEB was to fast-track the development and implementation of the nuclear power programme in order to enhance the production of affordable and reliable electricity in Kenya. Through the Energy Act, 2019, KNEB was transformed to Nuclear Power and Energy Agency (N*u*PEA) which is a State Corporation under the Ministry of Energy. The Act expanded the Agency's mandate to include promoting and implementing Kenya's Nuclear Power Programme, carrying out research and development, and capacity building in the energy sector.

In implementing the Kenya's nuclear power programme, N*u*PEA is following the International Atomic Energy Agency (IAEA) Milestone Approach [2] which is a guide document that breaks down the process of introducing the nuclear power programme into three phases and at the end of each phase there is a Milestone to be achieved. The Milestone guide document also has enumerated 19 infrastructure issues that an embarking country like Kenya needs to develop as shown in figure 1.

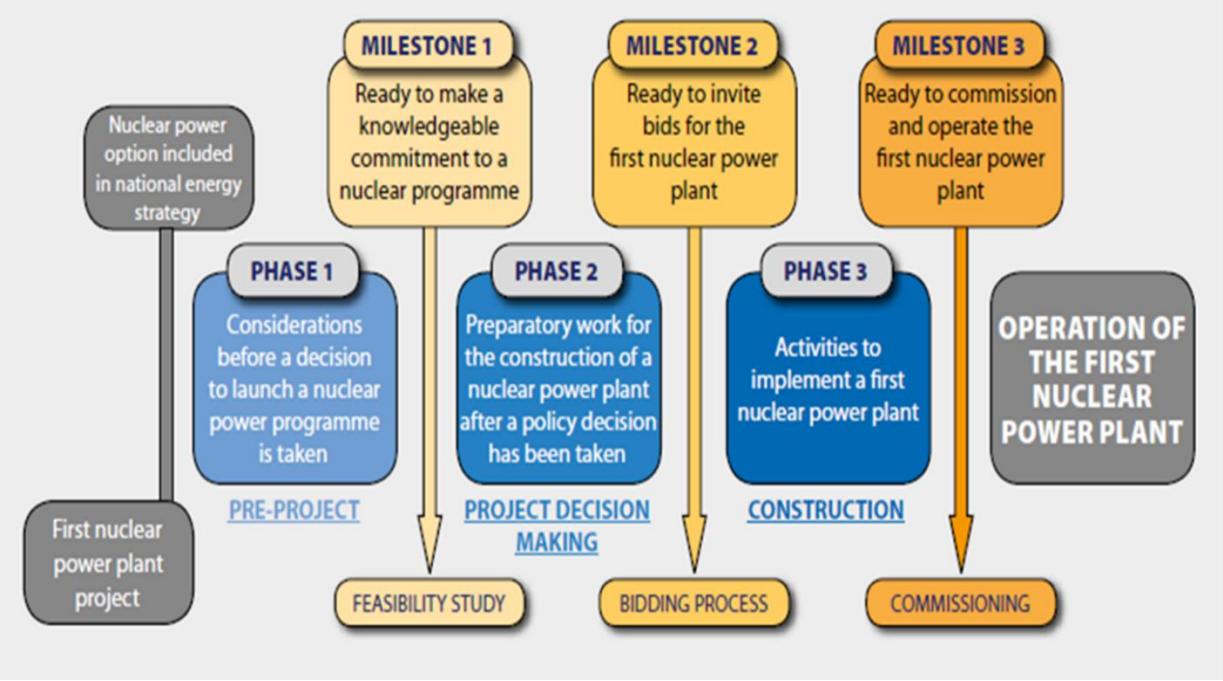

Figure 1. IAEA Milestone Approach

Figure 2: IAEA 19 Infrastructure issues

ACTIVITIES OF THE AGENCY

Since its establishment, the Agency has made significant milestones in the implementation of Kenya Nuclear Power Programme. Some of the key milestones include finalization of a Pre-Feasibility Study, establishment of cooperation and collaboration with stakeholders locally, regionally and internationally, enactment of the Nuclear Regulatory Act in 2019 and finalization of IAEA Integrated Nuclear Infrastructure Review (INIR), completion of technical studies in Electric Grid, Reactor Technology Assessment, Strategic Environmental Assessment and siting of the Nuclear Power Plant.

The Agency commenced an initiative to build human and institutional capacity to plan, develop and manage an efficient nuclear program in the country. In this the Agency has developed annual training programmes in various nuclear fields .The training comprises both short and long term programmes in partnership with international and local institutions of higher learning. For the Short term courses the Agency is training Kenyans through the International Atomic Energy Agency on Nuclear Technology (This includes Fellowships, Scientific Visits, Technical Meeting, Conference and Training Courses). Through the various Memorandum of Understanding (MoU) the Agency has entered with both locally and international partners, the Agency is training Kenyans in graduate and post graduate Masters in Nuclear engineering, nuclear Science and energy Policy.

CLIMATE CHANGE

Climate change is one of the greatest challenges of the 21st century. In response to this global threat, the international community reached the landmark 2015 Paris Agreement Under the United Nations Framework Convention on Climate Change (UNFCCC) (the Paris Agreement) setting clear objectives to keep a rise in global temperatures in this century well below 2°C above pre-industrial levels, and to pursue efforts to limit the temperature increase even further, to 1.5°C. Taking urgent action to combat climate change and its impact is also one of the 17 UN Sustainable Development Goals (SDGs) adopted in 2015.

In order to support the achievement of the Paris Agreement and SDGs and reach net zero emissions by 2050, all nations are called to scale up their ambitions and adopt concrete and realistic implementation plans compatible with these goals. Around 70% of the world's electricity currently comes from burning fossil fuels, according to the International Energy Agency. By 2050, around 80% of all electricity will need to be low carbon to meet the Paris Agreement goal.

ELECTRICITY GENERATION IN RELATION TO CLIMATE CHANGE

The emission of greenhouse gases (GHGs) and their implications to climate change have sparked global interest in understanding the relative contribution of the electrical generation industry. According to the Intergovernmental Panel on Climate Change (IPCC), the world emits approximately 27 Gigatonnes of CO2e from multiple sources with electrical production emitting 10 Gigatonnes, or approximately 37% of global emissions [5]. In addition, electricity demand is expected to increase by 43% over the next 20 years [3].

There are many different electrical generation methods, each having advantages and disadvantages with respect to operational cost, environmental impact, and other factors. In relation to GHG emissions, each generation method produces GHGs in varying quantities through construction, operation (including fuel supply activities), and decommissioning. Some generation methods such as coal fired power plants release the majority of GHGs during operation. Others, such as wind power and nuclear power, release the majority of emissions during construction and decommissioning. Accounting for emissions from all phases of the project (construction, operation, and decommissioning).

In arriving at the GHG emission levels form the different source of energy a lifecycle approach and normalization is done. This will ensure fair comparison of the different generation methods on a per gigawatt-hour basis. The lower the value, the less GHG emissions are emitted.

From the studies nuclear power, along with hydropower and wind energy, produces one of the lowest GHG emissions per unit of electricity generated on a life cycle basis as shown in table 1.

Table 1: Summary of Lifecycle GHG Emission Intensity

Technology	Mean	Low	High
		tonnes CO2e/GWh	
Lignite	1,054	790	1,372
Coal	888	756	1,310
Oil	733	547	935
Natural Gas	499	362	891
Solar PV	85	13	731
Biomass	45	10	101
Nuclear	29	2	130
Hydroelectric	26	2	237
Wind	26	6	124

In figure 3 a clear comparison is made from the different sources of electricity with the lifecycle of GHG emitted.

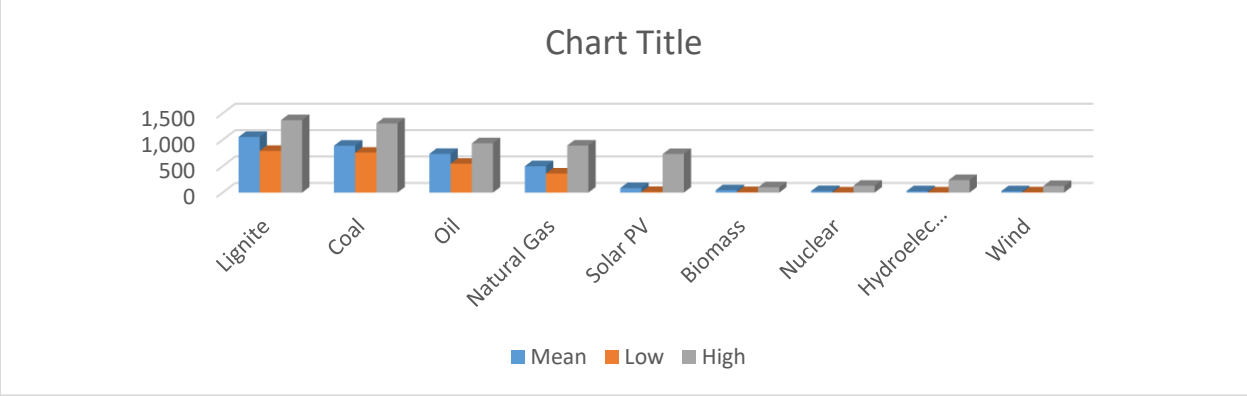

Figure 3: Comparison of Lifecycle GHG Emission Intensity

Further to the findings, the following observations can be made:

- Greenhouse gas emissions of nuclear power plants are among the lowest of any electricity generation method and on a lifecycle basis are comparable to wind, hydro-electricity and biomass.
- Lifecycle emissions of natural gas generation are 15 times greater than nuclear.
- Lifecycle emissions of coal generation are 30 times greater than nuclear.
- There is strong agreement in the published studies on life cycle GHG intensities for each generation method. However, the data demonstrates the sensitivity of lifecycle analysis to assumptions for each electricity generation source.

NUCLEAR TECHNOLOGY FOR ENVIRONMENTAL SUSTAINABILITY

Nuclear power saves almost 2 billion tonnes of carbon dioxide and other GHG emissions each year and has avoided more than 60 billion tonnes of emissions over the 1970- 2015 period [6].

The 442 nuclear power reactors currently in operation in 30 countries generated 10% of the world's electricity and one third of all low carbon electricity while avoiding approximately 2 Gt CO2 every year. It has great potential to play a significant role in achieving climate change mitigation goals and supporting social and economic development in the transition to a global low carbon economy.

Significantly greater and faster deployment of low carbon energy technologies, along with the phase-out of emission intensive sources, requires that all options be considered. As a large scale, reliable, dispatch-able, concentrated and low carbon energy source, nuclear power has contributed significantly in the past decades not only to GHG reduction but also to broader economic and social dimensions of sustainable development.

Although nuclear power has made a significant contribution to avoiding carbon emissions for the past 45 years, the challenge ahead is to keep pace with the demand for low-carbon energy to meet the 2˚C goal. Rapid deployment is constrained by long-term planning and construction times as well as industrial production limitations, especially for nuclear power plant components. In terms of unit construction requirements, the challenge is two-fold: replacing retiring units while also ramping up capacity in new markets. Replacing ageing capacity without causing a break or loss in output is a pressing issue for countries with the oldest nuclear power programmes.

Public support plays a key role in any nuclear power programme. The public must be confident that existing plants will continue to operate safely, and that new plants will be held to the highest of safety standards. Importantly, a robust safety culture at nuclear power plants must be maintained through continuous capacity building and open communication with stakeholders. To protect people and the environment from the harmful effects of ionizing radiation, the IAEA helps countries strengthen nuclear safety, emergency preparedness and radiation protection.

In advancing innovation to foster the deployment of more affordable and more sustainable low-carbon technologies [4]. For nuclear power, advancements can improve performance and safety and can help extend the operation life of reactors. Currently, nuclear power mainly supplies electricity, but innovation opens up additional areas to contribute to emission reduction, including non-electric applications such as desalination, process heat and energy storage. The Paris Agreement provides a platform for enhanced technological innovation and supports cooperation as well as knowledge transfer. There are many opportunities for innovation to advance nuclear energy in addressing climate change, including new reactor designs such as small modular reactors [23] and advanced fuel cycles. Some designs for innovative nuclear plants exist and many others are in development. However, more investment in research, development and demonstration is needed.

CLIMATE CHANGE IMPACTS IN KENYA

According to the Intergovernmental Panel on Climate Change (IPCC), as from 1950 the climate has changed the magnitude and frequency of extreme weather events in Africa. In Kenya during the past 50 years, surface temperatures in Nairobi have demonstrated a warming trend of more than 2.5^0C (Government of Kenya, 2018a). Other evidence of weather change is reduced rainfall due to shortened rainfall seasons. The impacts of climate change in Kenya can be categorized as social, environmental and economic. These include loss of infrastructure, agricultural produce and loss of life due to floods; community conflicts for land and water due to drought; signs of destruction in coastal areas through erosion and flooding caused by sea level rise; and coral bleaching that has disrupted marine ecosystems in the Western Indian Ocean resulting from increased sea temperatures. Significant impacts in the energy sector include reduction of hydroelectric power production capacity as water flows in rivers decline and damage to infrastructure (Government of Kenya, 2018b).

CLIMATE CHANGE ACTION PLAN IN ELECTRICITY GENERATION SECTOR

The country has developed a climate change action strategy to contribute in GHG emission reduction, this is known as National Climate Change Action Plan (NCCAP). Currently the country's greenhouse gas (GHG) emissions represent less than 1% of emissions in the world (Government of Kenya, 2018b). In this scenario the major focus of the country in climate change action would be adaptation, however national development plans in place and projected population growth require that the country develops mitigation actions. The NCCAP 2013-2017 established that the baseline GHG emission is projected to be 143 million tonnes of carbon dioxide equivalent ($MtCO_2e$) in 2030 whereby, electricity generation will be the highest emitter of GHG emissions in Kenya. In the period 2015-2030 the energy sector contribution to GHG emissions has been projected to increase, whereby electricity generation emissions grow upto 41 $MtCO_2e$ and energy demand emissions by 10 $MtCO_2e$. Much of the increase in electricity generation GHG emission is attributed to coal and natural gas which have been proposed for addition in the future energy mix (Government of Kenya, 2018a).

In the NCCAP 2018-2022, Kenya has set Nationally Determined Contributions (NDC) to mitigate GHG emissions by 30%; an emission potential of 42.9 $MtCO_2e$ by 2030. The emission potential for achieving this target has been distributed in six sectors, amongst them is electricity generation, which makes a contribution half its technical emission potential at 9.32 $MtCO_2e$. Table-2 outlines the emission potential in the six sectors.

Table 2 - National Emission Potential and the NDC Targets by Sector (Government of Kenya,2018a)

Sector	Greenhouse gas Emission Reduction Potential ($MtCO_2e$)				NDC Target ($MtCO_2e$)
	2015	**2020**	**2025**	**2030**	**2030**
Forestry	2.71	16.24	29.76	40.2	20.10
Electricity Generation	0.28	2.24	8.61	18.63	9.32
Energy Demand	2.74	5.16	7.92	12.17	6.09
Transportation	1.54	3.52	5.13	6.92	3.46
Agriculture	0.63	2.57	4.41	5.53	2.77
Industrial Processes	0.26	0.69	1.03	1.56	0.78
Waste	0.05	0.33	0.5	0.78	0.39
Total				**85.79**	**42.90**

SIGNIFICANCE OF CURRENT ENERGY PLAN TO NATIONAL CLIMATE CHANGE GOALS.

In the NCCAP 2018-2022 the key strategy proposed to meet the NDC target under the electricity generation sector is to increase the proportion of renewable energy and minimize the use of fossil fuel. This has been significantly supported by the Least Cost Power Development Plan (LCPDP) 2017-2037 whereby geothermal power plays a significant role in the energy mix. The LCPDP 2017-2037 gives a projection of the energy mix, in which geothermal energy is projected to provide the highest generation mix contribution between 2030 and 2037, at 25.9% and 26.7 % respectively. It is also expected that in this period wind and solar will make a significant contribution in the energy mix, at 11.9% and 10.8% respectively.

NUCLEAR POWER CONTRIBUTION TO NDCS

A projection on the implication of the Kenya energy mix for the period 2017-2037 on national climate change goals indicates that the uptake and use of coal and natural power plants will increase the country's GHG footprint (Government of Kenya, 2018a). Power supply is therefore expected to increase significantly to meet the projected demand growth. In order to achieve the set NDC target for the electricity generation sector, a combination of policies, programmes and technologies that promote low carbon development should be adopted. The National Energy Policy 2018 includes the use of nuclear technology for electricity generation. This implies that the key policy action required to ensure further emission reductions from the sector would be the restricted use or avoided installation of coal and natural gas capacity.

Nuclear electricity offers a great opportunity for Kenya to meet its emission reduction target as it is one of the energy sources with less GHG emissions. Adoption of nuclear power generation not only contributes to meeting emission reduction target in Kenya but also offers a reliable source of baseload electricity that is also resilient to climate change. Besides the reliability and predictability that nuclear power offers in the electricity markets, it also has non- climatic environmental benefits and minimizes the impact on human health as it emits practically no local or regional air pollutants. Among the power generation technologies, nuclear has the lowest external costs in terms of damage to human health and the environment.

CONCLUSION

Kenya has recognized the potential benefits of adopting nuclear power and has taken the policy decision to include it as a technology option in its national energy policy. This decision has been taken against a background of exponentially increasing energy demand arising from accelerated socio-economic growth on the one hand, and concomitant dwindling supplies of energy on the other. The combined effect of this mismatch in demand versus supply has resulted in high costs of energy domestically and industrially.

The national energy policy serves the core function of providing the enabling framework for the operation of the nuclear energy, setting out goals and action points over the short, medium, and long-term. Commendably, the policy has recognized the important role that research and development (R&D) activities play in promoting the emergence of innovative technologies across the energy sector.

This paper has affirmed that nuclear energy can indeed make development sustainable from an energy perspective. This sustainability can be achieved through the establishment of robust nuclear power programme infrastructure, which possess the hybrid character of 'functional effectiveness' and 'regulatory efficiency', coupled with suitable performance indicators.

Clean and sustainable energy is essential for Kenya's sustainable development and is considered one of the infrastructure enablers of the socio-economic pillar of Vision 2030. Besides the reliability and predictability that nuclear power offers in the electricity markets, it also has non-climatic environmental benefits and minimizes the impact on human health as it emits practically no local or regional air pollutants. Among the power generation technologies, nuclear has the lowest external costs in terms of damage to human health and the environment.

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