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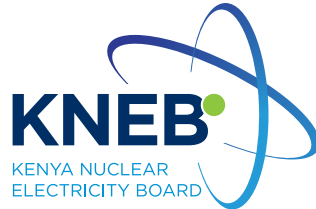
A Publication of the Nuclear Power and Energy Agency



NEW DAWN ENERGY ACT 2019

NUCLEAR POWER AND ENERGY AGENCY (NuPEA)

Formerly



PUBLIC NOTICE ON CHANGE OF NAME

This is to notify the general public that following the enactment of the Energy Act, 2019, **Kenya Nuclear Electricity Board (KNEB)** has changed its name to **Nuclear Power and Energy Agency (NuPEA)** with effect from 28th March, 2019. The new mandate entails:

- i. Development of Nuclear Power Programme for electricity generation in Kenya.
- ii. Carrying out research for development of energy technologies and capacity building for the energy sector.

NuPEA is currently in transition to fully align itself to its new mandate and relevant laws and shall continuously inform its stakeholders on key developments.

We shall be grateful to receive and respond to any queries related to or consequential to the name change. Inquiries may be sent to info@nuclear.co.ke/
ceo@nuclear.co.ke.

All contractual relationships and obligations that the organization has with its customers, partners and other stakeholders are not affected by this name change.

By order of the Board

CHIEF EXECUTIVE OFFICER
NUCLEAR POWER & ENERGY AGENCY (NuPEA)



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Editorial Director Basett Buyukah **Sub Editor** Emmanuel Wandera **Contributors** Basett Buyukah, Carl Madara, Emmanuel Wandera, Katua Muinde, Faith Kosgei, Jonathan Njoroge, Esther Musyoka, Sakwa Khalid, Collins Owino, Nathalie Mikhailova, Brenda Esilaba, Laura Gil **Design & Layout** Carl Madara, **Photography** Carl Madara, **Circulation** Dennis Nkonge

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CEO'S MESSAGE

Welcome to Fission Issue 14 that highlights activities for the period from January to June 2019. This is the second half of the Government financial year that begins on first July of the current calendar year and ends on 30th June of the coming year.

During this period that organization has experienced very significant changes and transition. At the apex, the organization experienced transition at the Board of Directors level, where the term of the immediate former Board of Directors expired, paving way for appointment of new Directors. This was highlighted by the appointment of Eng. Ezra Odhiambo as the chairperson of the NuPEA Board of Directors.

Another transition was transformation of Kenya Nuclear Electricity Board(KNEB) to Nuclear Power and Energy Agency (NuPEA) after the ascension of Energy Act 2019 into law by the President of the Republic of Kenya H.E. President Uhuru Kenyatta on 14th March 2019.

Key during this period was the public hearing on yet another critical bill, the Nuclear Regulatory Bill, 2019 by the National Assembly's Departmental Committee on Energy in partnership with NuPEA and the Radiation Protection Board. The Bill is important in the establishment of an independent nuclear regulatory authority that will protect the people, property and the environment from the harmful effects of exposure to radiation and to provide for nuclear safety and non- proliferation in accordance with national and international obligations.

Stakeholder engagement, education and information are the cornerstone for a successful nuclear power programme. This is true as Kenya Nuclear Electricity Board (KNEB) has focused on public sensitization through a number of activities and programs.

Stay tuned and enjoy reading this issue as we share what the Nuclear Power and Energy Agency is undertaking in developing the processes, structure and roadmap for Kenya's first nuclear power plant.



Eng. Collins Juma
CEO

ENG. COLLINS JUMA

CEO

EDITORIAL

Welcome to the fourteenth edition of the Fission Magazine. In this issue, as is custom we take a broad look at the news and events that have occurred as Kenya continues apace on the odyssey toward nuclear electricity generation.

In our cover story, we focus on the outreach by the Nuclear power and Energy Agency in tandem with the National Assembly's Energy Committee and The Radiation Protection Board. The extensive public hearings for the Nuclear Regulatory Bill and the civic education and sensitization on Kenya's nuclear power programme were a fillip in enhancing public understanding of this important issue.

We give you an explainer on the Energy Act and its impact on the organization as it transitions from the Kenya Nuclear Electricity Board to the Nuclear Power and Energy Agency, complete with an expanded mandate for energy research and capacity building.

Plus we go round the happenings and events that defined the period including the Nuclear Career talks for tertiary institutions, Energy Management Awards, the International Forum AtomExpo 2019 and Environmental conservation through tree planting.

Still in this edition, we get insights from a KEPCO International Nuclear Graduate School alumnus, on academic and social life while on campus in South Korea.

On the technology front, we trace the origins of nuclear energy right here on the African continent and get a perspective on the progress toward final repositories for safe disposal of spent nuclear fuel.

That's not all, there's an intern's testimony of experiences on the job and we go up close and personal in the Interview section.

Welcome. Enjoy the read.



Basett Buyukah

Director Publicity & Advocacy

BASETT BUYUKAH

EDITORIAL DIRECTOR

KENYA NUCLEAR ELECTRICITY BOARD CHAIRMAN AND MEMBERS NAMED



Eng. Ezra Odondi Odhiambo

Chairman

On 8th February 2019, President Uhuru Kenyatta appointed Eng. Ezra Odondi Odhiambo to be the Chairman of the Kenya Nuclear Electricity Board for a period of three years. This is under section 7(1) (a) of the Kenya Nuclear Electricity Board Order, 2012, State Corporations Act. This was contained in the Kenya Gazette Notice no. 1204 of 8th February 2019.

In the same edition under Gazette Notice no 1223, Energy Cabinet Secretary, Hon. Charles Keter appointed Dr Kipkorir Koross Geoffrey Kiptoo, Hon. Josephine Odira Sinyo, Ms Teresiah Mbaika Malokwe and Mr. Stephen Mwangi Karanja as Board members for a period of three years in exercise of powers conferred by paragraph 7 (1) (f) of the Kenya Nuclear Electricity Board Order 2012.



**Dr Kipkorir Koross
Geoffrey Kiptoo**



**Ms Teresiah Mbaika
Malokwe**



**Hon. Josephine Odira
Sinyo**



**Mr. Stephen Mwangi
Karanja**

A NEW DAWN: TRANSITION FROM KNEB TO NuPEA



President Uhuru Kenyatta signs Energy Bill 2017, Urban Areas and Cities (Amendment) Bill 2017 and Petroleum Bill 2017 at State House in Nairobi on March 12, 2019.

By Katua Muinde

The enactment and presidential assent by H.E President Uhuru Kenyatta of the Energy Act 2019 into law on 14th March 2019, has not only transformed Kenya Nuclear Electricity Board (KNEB) to Nuclear Power and Energy Agency(NuPEA) but has had far reaching ramifications for the entire energy sector.

The Energy Act 2019 has led to a rebirth by relaunching a number of institutions under the Ministry of Energy with added mandate. The Act establishes the Energy and Petroleum Regulatory Authority, the Rural Electrification and Renewable Energy Corporation and the Nuclear Power and Energy Agency (NuPEA).

This is a shot in the arm for Kenya's nuclear power programme. The Act transforms KNEB into NuPEA

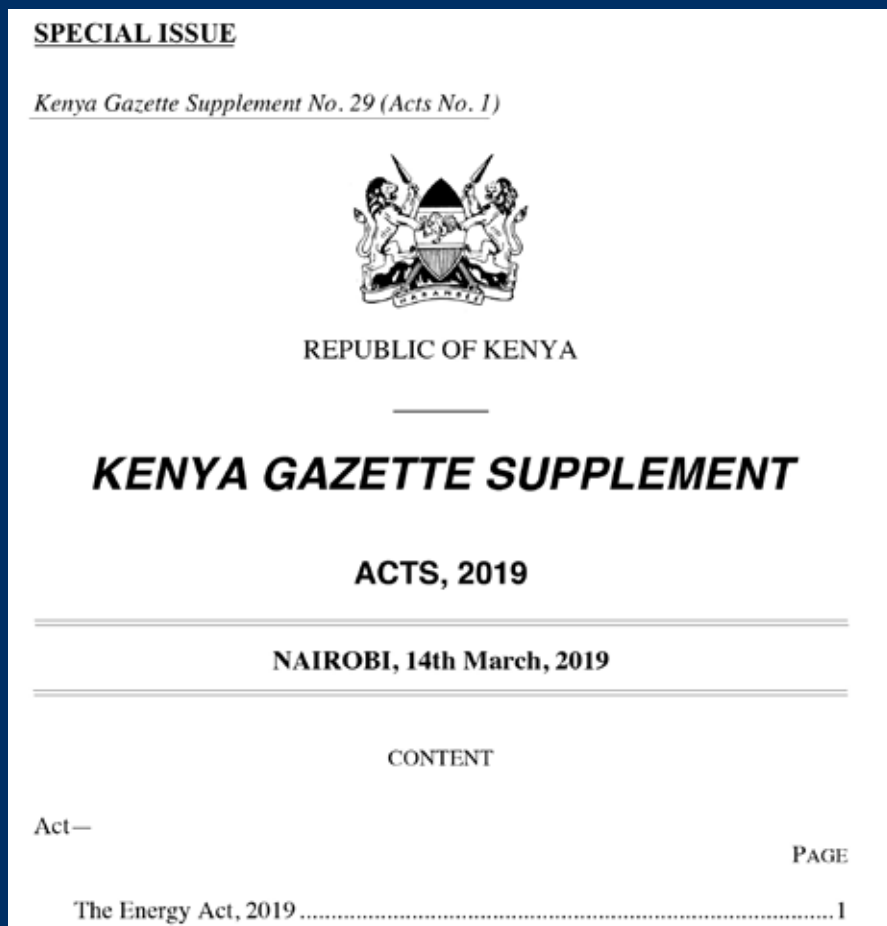
with an expanded mandate. Where previously KNEB's main mandate was to Promote and expedite the development of nuclear electricity in Kenya but under the new law, NuPEA shall in addition carry out research, development and dissemination of activities in the energy sector and nuclear power sector. NuPEA will propose policies and legislation for the successful implementation of a nuclear power programme and finally undertake extensive public education on Kenya's nuclear power programme.

The establishment of NuPEA under the Energy Act 2019, demonstrates Kenya's commitments and enthusiasm in embracing of safe, reliable, affordable and carbon-free nuclear technology for electricity generation when the country commissions its first 1000Mw nuclear power plant. This gives Kenya an opportunity to diversify its energy mix and reduce dependency on non-renewable energy sources for the realization of vision 2030.

NuPEA is currently in transition to fully align itself to its new mandate and relevant laws and is continuously informing its stakeholders on key developments. Some of the transition activities include: rebranding, notifying our stakeholder on the change of name, designing a new logo, revision the organization strategic plan, unbundling the expended mandate for operationalization, running media campaigns and public sensitization.

It is noteworthy that all contractual relationships and obligations that the organization has with its customers, partners and other stakeholders are not affected by the name change.

As part of the metamorphosis, this is the third change that the organization is undergoing from inception in 2010 as Nuclear Energy Project Committee(NEPC), to Kenya Nuclear Electricity Board (KNEB) in 2012 and now Nuclear Power and Energy Agency (NuPEA).



The Energy Act, 2019 that led to the formation of Nuclear Power & Energy Agency

PUBLIC HEARINGS HELD ON NUCLEAR REGULATORY BILL 2018



Nuclear Power and Energy Agency (NuPEA) Chairman Eng. Ezra Odhiambo delivers his address during a Public hearing on the Nuclear Regulatory Bill 2018 at Nkoroi in Kajiado County. Seated front row l-r: NuPEA CEO Eng. Collins Juma, Butere MP Tindi Mwale, Gem MP Elisha Odhiambo, Endeless MP Robert Pukose and Kajiado North MP Joseph Manje.

By Faith Kosgei

Nuclear Power and Energy Agency (NuPEA) in collaboration with Radiation Protection Board (RPB) and The National Assembly's Departmental Committee on Energy conducted the Nuclear Regulatory Bill 2018 Public hearings across eleven counties between 22 March 2019 to 16th May 2019.

The proposed legislation aims to ensure protection of people, property and the environment from the harmful effects of exposure to radiation and to provide for nuclear safety and non- proliferation in accordance with national and international obligations.

The passage of the Bill would have the effect of repealing the existing Radiation Protection Act. It provides for a

comprehensive regulatory framework, including safety measures in carrying out nuclear energy activities and associated waste.

Public participation is a constitutional requirement in developing legislation in Kenya. Thus, the National Assembly's departmental Committee on Energy, in partnership with NuPEA and the Radiation Protection Board conducted public hearings across the country. These offered a platform for Kenyans to provide their input for the Nuclear Regulatory Bill.

Speaking during the public hearing at Mwingi, Kitui County, NuPEA Chairman Eng. Ezra Odhiambo underscored the important role energy plays in driving the country's development, including the big four agenda.

"Kenya requires an estimated 16,000 megawatts of electricity by 2030 and with this, nuclear energy has been identified as a stable, efficient and reliable source of electricity to spur industrial development and stimulate economic growth. In order to achieve we need rules and regulations to ensure the technology is deployed in safe manner and thus this bill is very important not only to NuPEA but the whole country, said Eng. Odhiambo.

During the public hearing a number of concerns and fears were raised that included: why is Kenya going Nuclear given the disasters that have been reported in Europe and other areas about it, what are the advantages and disadvantages of Nuclear Energy, why does it takes long to establish nuclear plants in Kenya, why is Kenya pursuing nuclear energy whereas there is other sources of energy in Kenya, why Kenya is pursuing nuclear and yet it is very expensive regarding the state of corruption in the country at the moment, how safe are nuclear plants with regards to security, harmful radiation and waste disposal measures, the phase at which Kenya's Nuclear power programme is as of now and why Kenya is going nuclear yet countries such as Germany are running away from nuclear Projects.

By the end of the public hearings most of the concerns and fears allayed were addressed by NuPEA team, RPB team and members of the National assembly departmental Committee on Energy Chairperson Hon. David Gikaria and his team.

'The Draft Nuclear regulatory Bill have provisions to deal with the fears that had been raised and the operations of a nuclear power plant does not have adverse effects on humans and the environment adding that Kenya has adopted the global safety requirements in the Bill, 'said Hon. Gikaria across the 11 counties visited.

Counties that Public hearings were conducted included: Kitui, Kiambu, Mombasa, Kilifi, Kwale, Nairobi, Eldoret, Busia, Nakuru, Kericho and Kajiado

The Nuclear Regulatory Bill 2018 was published by Kenya's National Assembly on November 19, 2018 in the Kenya Gazette Supplement No.143 (National Assembly Bills No.27).



PICTORIAL

The Nuclear Regulatory Bill 2018

Nuclear Power and Energy Agency (NuPEA) in collaboration with Radiation Protection Board (RPB) and The National Assembly's Departmental Committee on Energy conducted the Nuclear Regulatory Bill 2018 Public hearings across eleven counties namely Kajiado, Nakuru, Kericho, Kisumu, Busia, Eldoret, Kwale, Kilifi, Mombasa, Kiambu and Mwingi North between 22 March 2019 to 16th May 2019.

Here are Images from the public hearings held in the counties



KENYAN LEGISLATORS ATTEND ATOMEXPO CONFERENCE IN SOCHI, RUSSIA



1

Kenyan legislators helmed a high-powered delegation to the 11th International Forum ATOMEXPO 2019 held in Sochi, Russia between 14th – 16th April 2019. The picturesque city on the shores of the Black Sea was the gathering for this important annual event in the global nuclear calendar.

Organized by the Russian State Agency for Nuclear Energy (ROSATOM), it provided a singular opportunity to interact with a broad spectrum of nuclear energy experts from diverse backgrounds.

The Kenyan delegation was led by Chief Administrative Secretary in the Ministry of Energy, Simon Kachapin. From the National assembly, five members of the Departmental Committee on Energy were present led by the Vice Chair Hon Dr Robert Pukose. Others were Hon Amina Gedow, Hon Mohammed Lokiru, Hon Tindi Mwale and Hon Muturi Kigano. Also in the delegation were two Senators, Jones Mwaruma and Dr. Ochilo Ayacko.

The Nuclear Power and Energy Agency who were the organizers of the visit had CEO, Eng. Collins Juma, Chairman Eng. Ezra Odhiambo, Board member Dr Kiptoo Koross as well as Director, Publicity and Advocacy, Basett Buyukah.

The conference kicked off with the ROSATOM Sailing Cup. This was an informal opportunity for delegates to unwind and network ahead of the conference deliberations. During the competition which had ten teams, Hon. Kachapin and his fellow sailors scooped second position

overall.

During the conference itself, members of the Kenyan delegation were able to access the latest information about future development of the nuclear industry besides sharing experiences in international and cross-sector environments. The exhibition during the event enabled various companies and entities involved in the nuclear energy sector to showcase their products, achievements, innovations and scope for possible cooperation with Kenya and other emerging countries in the field.



2



3



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6



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1. The delegation at the AtomExpo 2019 venue in Sochi 2. NuPEA Director Publicity and Advocacy Mr Basett Buyukah during a panel discussion at the AtomExpo2019. 3. Second-place team in the ROSATOM International Sailing Cup receive their tokens 4. Hon Muturi Kigano, NuPEA Chairman Eng. Ezra Odhiambo, NuPEA Board member Dr Kiptoo Koross and Vice Chair of the National Assembly’s Energy Committee Dr Robert Pukosetake in the sights and sounds of Sochi City during a cultural event of the AtomExpo 2019 5. Energy Chief Administrative Secretary Simon Kachapin on the podium with his ROSATOM Sailing Cup teammates 6. NuPEA Chairman, Eng. Ezra Odhiambo(left) with his predecessor Senator Ochilo Ayacko.

TERTIARY STUDENTS VISIT KAWI HOUSE FOR NUCLEAR CAREERS TALK



Kabete National Polytechnic Students during the Nuclear Careers Talk held at the Kawi Complex Auditorium on 25th June 2019.

By Emmanuel Wandera

On June 25 2019, more than one hundred students drawn from various institutions of higher learning converged at KAWI Complex auditorium for a nuclear careers talks. This is a programme that the Nuclear Power and Energy Agency (NuPEA) conducts for educational institutions where staff give career advice and counsel to students on career choices. Through this interaction, students discern the potential opportunities that Kenya's nuclear power programme can offer them.

Present during the event were students drawn from the University of Nairobi's Departments of physics and engineering respectively, Jomo Kenyatta University of Agriculture and Technology (JKUAT), Kenyatta University, Nairobi Institute of Business Studies (NIBS) Technical College and Kabete National Polytechnic. Accompanying the students during the talk were their Deans.

The talk sought to challenge, engage and spur nuclear technology discussions amongst students in order to create awareness, address myths and facts surrounding nuclear technology while offering careers insights.

NuPEA Director of Human Resource and Administration Sophia Githuku who was elated thanked the

lecturers and students for their enthusiasm and eagerness to attend the career talk.

'I am happy to see young Kenyans who will play a pivotal role in Kenya's nuclear power programme ready to engage on issues pertaining careers and nuclear science and technology,' said Githuku.

NuPEA's Senior Communication Officer, Emmanuel Wandera and Senior Technical Officer, Kenneth Anakoli took students through an introduction to Nuclear Power and Energy Agency, the career spectrum in the nuclear industry and nuclear energy uses and benefits. Discipline, confidence and hard work were highlighted as recipes for success.

The careers talk entailed presentations from NuPEA staff on careers, nuclear science and technology as well as a plenary session. Students were also made conversant with the technology by viewing a nuclear power plant model which is housed in the



Top: NuPEA's Director for Human Resource and Administration, Sophia Githuku delivers the opening remarks during the Nuclear Careers Talk held at the Kawi Complex Auditorium on 25th June, 2019.

Below: Students from Nairobi Institute of Business Studies Technical College during the Nuclear Careers Talk.



NuPEA premises.

Eng. Francis Ngokonyo who is the the Dean of the Faculty of Engineering Kenyatta University thanked NuPEA for organizing such a fruitful event for students.

'This kind of engagement is very important to lecturers and students because it links industry and academia by reinforcing what we have taught students in class,' said Eng. Ngokonyo.



some of the students viewing a model of a nuclear power plant.



NuPEA PROMOTES SCIENCE & INNOVATION AT THE 2019 KENYA SCIENCE AND ENGINEERING FAIR NATIONAL COMPETITION



NuPEA's Senior Corporate Affairs & Communication Officer Emmanuel Wandera (Standing) talks nuclear matters with young innovators at the 2019 Kenya Science and Engineering Fair National Competition at Jomo Kenyatta High School, Nakuru County.

By Jonathan Njoroge & Emmanuel Wandera

From 8th -11th April, the Nuclear Power and Energy Agency (NuPEA), formerly Kenya Nuclear Electricity Board (KNEB), in its quest to promote Science and Innovation amongst upcoming scientists pitched tent at the 2019 Kenya Science and Engineering Fair National competition at Jomo Kenyatta High School in Nakuru County.

The four-day event brought together over 1500 young innovators from High schools drawn from across the country and 500 teachers who mentored the students in coming up with their innovations that were

exhibited in the Science Fair. This presented a unique opportunity for NuPEA to engage young innovators on nuclear energy development in Kenya.

The 2019 Kenya Science and Engineering Fair (KSEF) was marked by innovation and ingenuity, which carried the day. This was evident as the chief Guest H.E Dr. Eric Korir, the Deputy Governor of Nakuru County lauded the students for great innovations.

‘ I can comfortably state from what I have seen here today, that Kenya’s vision 2030 is in safe hands and the country’s future is bright with this young scientists and innovators leading the way,’ said Deputy Governor Korir.

In the bid to promote science and innovation NuPEA has always partnered with the ministry of Educations, the organizers, to reward winners in Physics, Engineering and Energy categories by way of trophies and cash vouchers for their outstanding innovations. This is the fifth year in a row that NuPEA is sponsoring Kenya Science and Engineering Fair national competitions.

During the Fair, NuPEA had an opportunity to interact with students and teachers through sensitization about nuclear energy.

Cheers and jubilation from the students marked the awards ceremony particularly the schools that won specific categories. Turning the projects into business opportunities was discussed at length by the organizers and sponsors. The discussion culminated in one of the sponsors offering to invest in the top two projects to turn them into business ventures envisaged to help the students cash in on their innovations. The students with overall best project will represent Kenya in the United States of America in the year 2020 at International Science Fair competition.



N u P E A ' s Emmanuel Wandera (Left) handing over trophy donations from the organization to Kenya Science & Engineering Fair national officials at the 2019 Kenya Science and Engineering Fair National Competition, Jomo Kenyatta High School, Nakuru County.

NuPEA SPONSORS ENERGY MANAGEMENT AWARDS, 2019 EDITION



Winner: EABL emerges as the overall winner in the Energy Management Awards 2019

By Esther Musyoka

It is yet another year of partnership between NuPEA and Kenya Association of Manufacture (KAM) in promoting energy management. This is under the Energy Management Awards, popularly known as EMA awards. This year marks the 14th Edition of EMA Awards with the event being held on 10th - 12th April 2019 at the Safari Park Hotel, Nairobi.

NuPEA participated by way of sponsoring the event in Bronze category and setting up an exhibition stand to interact with participants by addressing their concerns while familiarizing them with the progress and milestones achieved to-date in Kenya's nuclear power programme.

Kenya Association of Manufacturers is not only a key stakeholder in the development of the nuclear power

programme for electricity generation in Kenya but also a partner in promoting energy efficiency in the manufacturing industry in small, medium and large enterprises.

The three-day build-up to the Awards ceremony was eventful. Day one and two was marked by Sustainable Energy Conference characterized by keynote speeches, presentations and panel discussions revolving around energy matters that ran concurrently with exhibitions by various energy utilities and corporate exhibitors.

The climax of Day three was the exciting Awards Gala that saw nominee enterprises in the various EMA awards categories get recognized and awarded trophies for their great work.

As Kenya continues the preparatory activities toward constructing its first 1000MW nuclear power plant for electricity generation, NuPEA is keen and committed in promoting energy efficiency by EMA awards among other initiatives. This is the fifth time that NuPEA has partnered with the Kenya Association of Manufacturers as one of the sponsors of the Energy Management Awards.



NuPEA JOINS OTHER ENERGY SECTOR UTILITIES AT MEDIA AWARDS LAUNCH CEREMONY



NuPEA Chairman Eng. Ezra Odhiambo (extreme left) sharing a light moment with KETRACO Managing Director FCPA Fernandes Barasa, Kenya Power Ag. Managing Director Eng. Jared Othieno and National Oil Corporation of Kenya CEO Ms. Mary Jane Mwangi during EJEIA IV Launch at Nairobi Safari Club.

By Emmanuel Wandera

On 14th January 2019, Nuclear Power and Energy Agency (NuPEA) in collaboration with other energy sector utilities launched the fourth edition of Energy Journalism Excellence Awards (EJEIA IV) at Nairobi Safari Club Hotel in Nairobi.

The awards were officially launched in a colorful event heralding the call for entries. It was attended by Energy sector bigwigs and journalists. Unveiling the awards was, the Chief Guest, Principal Secretary

(PS) in the Ministry of Energy, Dr. Eng. Joseph Njoroge who said Government was keen to bring in more renewables power projects as a way of supporting the Big Four Agenda and require media partnership.

Present during the launch were the Principal Secretary, Petroleum Andrew Kamau, Kenya Pipeline Company (KPC) Chairman John Ngumi, Kenya Pipeline Company Ag. Managing Director Hudson Andambi, KETRACO Managing Director Fernandes Barasa, Kenya Power Ag. Managing Director Eng. Jared Othieno, NuPEA Chairman Eng. Ezra Odhiambo. Others present included NuPEA CEO Eng. Collins Juma, National Oil Corporation of Kenya (NOCK) CEO Ms. Mary Jane Mwangi and Heads of Communication in the energy sector, journalists and News Editors.

EJEA is an initiative that started in 2014 by the Ministry of Energy and its parastatals, as a platform to build mutual and beneficial relationships with the media while promoting quality energy journalism in the country. This is through accurate and factual reporting of energy matters.

Speaking during the Launch, the Chief Guest Dr. Eng. Joseph

Njoroge thanked the media for continued support since the inception of EJEA and called on them to foster closer working relationship with agencies in the energy and petroleum sub-sector.

‘The media has a pivotal role in monitoring and conveying the correct and timely information to the public and it is the duty of each agency to provide it,’ said PS Njoroge.

He emphasized that media have a duty to communicate clearly to the broad spectrum of Kenyan society and make them understand what programs and initiatives Government is undertaking in the key focus of food security, affordable housing, manufacturing and universal healthcare.

Before the launch, NuPEA together with other energy sector utilities conducted media training across the country where more than 500 journalists and news editors were sensitized on Kenya’s energy sector, role of each entity and nuclear technology in the energy mix.

Nuclear energy has a special category in the awards. The winner of the nuclear category earns a study tour to a country operating a nuclear power plant to learn more about nuclear technology first hand. This endows journalists with skills for nuclear energy reporting.



Chief Guest Ministry of Energy PS Dr. Eng. Joseph Njoroge delivers his remarks.



Communication Managers from the various agencies in the Energy and Petroleum sectors during the launch



NuPEA CEO Eng. Collins Juma confers with Energy Principal Secretary, Dr. Eng. Joseph Njoroge during the ceremony.

LIFE AND STUDY IN SOUTH KOREA: THE WHYS AND WHEREFORES

By Collins Owino

The mind is not a vessel to be filled, but a fire to be kindled! Applying for the Korea International Nuclear Graduate School (KINGS) scholarship was the best decision I have ever made in my career as an engineer.

I'm a research assistant at Nuclear Power and Energy Agency (NuPEA), formerly Kenya Nuclear Electricity Board (KNEB). For The Past two years, I have been undertaking a Masters programme in Nuclear Power Plant Engineering at KEPCO International Nuclear Graduate School (KINGS) in South Korea Wollae Town. Wollae is located at the beautiful shores of the East Sea with a breathtaking view of the sunshine and in close proximity to the Kori Nuclear Power Plant Complex.



KINGS strategic location presents students with easy access to practical learning and this, by all standards, bolsters the theory learnt in class. Additionally, KINGS campus offers an optimal academic environment and a venue for cultural exchange to the students from diverse cultures around the world, providing various conveniences as a space for study and relaxation.

KINGS admits international students from all over the world, together with Korean students for the Nuclear Power Plant Engineering Masters Programme. As per the school motto: "uniqueness is better than the best," this program offered in six trimesters is tailored to nurture and develop all round future leadership-level professionals in nuclear field with practical competence irrespective of their undergraduate background.

The first year focuses on the basics and comprehensive Knowledge on nuclear power "know-what" and "know-how" that is, applying principles and processes of system engineering to the field of nuclear power and essential knowledge necessary for introducing nuclear power plant for the first time in a country such as Kenya. The second year, is about "know-why" where a student specializes based on project courses, from this nuclear power plant Engineering is a very intensive course that requires a lot of teamwork (Team learning and team teaching).

The most unique thing about KINGS that I would wish Kenya higher learning institution to emulate is the never ending urge for the professors to impart knowledge and offer mentorship to all cadre of students from various countries and institutions while taking into account their academic, experience and cultural diversities.

Additionally, all the professors are nuclear industry experts, having worked on nuclear projects and businesses as professionals for many years. Their work experience in the corporate world and industry is priceless.

In spite of the cultural diversity, Koreans are honest and hospitable people especially to foreigners. They don't wave hands to say "annyeonghaseyo" (hello) or bye to the senior or elderly people instead they bow to show courtesy.

The highly efficient transport system is only second to the Japanese. The Cities are connected by subway and buses with directions guides written both in Hangeul, Chinese, Japanese and English. This is convenient for non-natives especially during peak hours. The city streets are packed with a bunch of tea and coffee shops, markets and dozens of carts selling various kinds of street food with everything from grilled octopus on stick to delicious custard cake.

From my two years' experience and stay in South Korea, I can confidently say that generally Kenya can learn a lot from countries such as South Korea in seeking to spur its economic development. In respect of nuclear power development, Kenya has taken some notable steps including collaboration with Korean institutions (academic and research) on matters of nuclear power programme.

Kenya should take inspiration and seek to emulate the lessons learned from the transformation of Korea, from the ruins in the aftermath of the Korean War to a prosperous, developed country with one of the largest economies on the globe.



Collins (Second from Left) with fellow students on the graduation day.

INTERESTING FACTS ABOUT NUCLEAR REACTORS



Just one uranium fuel pellet - roughly the size of the tip of an adult's little finger - contains the same amount of energy as 17,000 cubic feet of natural gas, 1,780 pounds of coal or 149 gallons of oil



Nuclear energy is being used in more than 30 countries around the world, and even powers Mars rovers



A typical nuclear plant can generate enough electricity to power 690,000 houses without creating air emissions



13 percent of the world's electricity comes from nuclear power plants that emit little to no greenhouse gases



A typical nuclear reactor works 24/7 at a 90% average capacity factor



A typical nuclear reactor on an average refuels 1/3rd of fuel every 18th month

THE LARGEST PRODUCERS OF NUCLEAR POWER ARE THE US, FRANCE AND JAPAN.



Crossword Puzzle Answers

<p>19. Dose</p>	<p>Down</p> <p>1. Radiation 3. Kinetic 5. Energy 6. Gamma 7. Thorium 9. Fission 11. Electrons 12. Austria 14. Uranium 16. Beta</p>	<p>Across</p> <p>2. Alpha 4. Atom 8. Irradiate 10. Cancer 13. Isotope 15. Absorber 17. Power 18. Ion 20. Nucleus 21. Atomic mass</p>
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Country Nuclear Profile in Africa

	Country	Status
1.	Egypt	Site preparation for first four NPP with a total of 4800 MWe is underway.
2.	South Africa	Two reactors currently in operation at Koeberg with total installed capacity of 1,800MWe
3.	Nigeria	30kW research reactor in operation. Nigeria Nuclear Regulatory Authority (NNRA) was set up for regulatory oversight on all uses of ionizing radiation. Nigeria Atomic Energy Commission (NAEC) announced selection of four sites for further evaluation. Signed a cooperation agreement with Russia including provision for uranium exploration and mining in the country.
4.	Ghana	30kW research reactor in operation. Nuclear Regulatory Power Act to establish an independent regulator – Ghana Nuclear Regulatory Authority (NRA) - was passed by Parliament in 2015.
5.	Kenya	Plans to realize NPP by 2027. Agreements of assistance in Nuclear Power Development with Russia, China and Korea have been signed. Nuclear energy policy to set up the national nuclear regulator is pending presidential ascent. Site selection is underway.
6.	Uganda	Government signed an agreement with IAEA to initiate the provision of a framework to develop nuclear power generation.
7.	Tanzania	Government has expressed an intention to investigate the use of nuclear power
8.	Zambia	Agreement between Rosatom and Ministry of Education for the construction of the center for Nuclear Science and technology in Zambia, with a 10 MWe research reactor.
9.	Namibia	The government has committed to a policy position of supplying its own electricity from nuclear power given that the country holds about 7% of the world's uranium reserves.
10.	Tunisia	Evaluation of possible construction of a 600 - 1000 MWe NPP by the government is underway.
11.	Libya	10MW research reactor present. Development of Institutional infrastructure for setting up a NPP currently underway. A site for both power generation and desalination has been selected.
12.	Algeria	Two research reactors currently operating. Signed agreements with Rosatom and China for design, construction and operation of NPPs and nuclear research respectively.
13.	Morocco	2MW Triga research reactor under construction. Pre-project study for desalination is complete. Government has approved setting up of a Nuclear Safety Agency
14.	Sudan	Government set up the Nuclear Energy Generation Department. Plans to have an NPP with four 300-600 MWe or 4400 MWe operating by 2030

INTERNSHIP EXPERIENCE AT THE NUCLEAR POWER AND ENERGY AGENCY

By Sakwa Khalid



My experience working as an Intern at Nuclear Power and Energy Agency (NuPEA) has been quite interesting. What I have gained so far has transformed me and I feel more confident and ready to kickstart an illustrious career in my field of study.

It is now a while since I started internship here and the experience at NuPEA has prepared me for the future. As an IT intern, I am learning some important skills and discovering new ideas needed in order to stay in the field of Information Technology (IT) and make my dream come true.

Working at NuPEA has made me understand some important aspects of being successful in ICT. One thing I have learnt is that communication is an essential aspect of learning at the work place. Thus, one should be able to communicate with fellow employees and ask the right questions at an appropriate time. Multitasking will make one flexible at work and punctuality will make one shine and be more efficient in delivering in your tasks and assigned duties.

Another key to success is having a great professional attitude towards work. Networking with people will enable one to fit in the competitive job market in order to learn new skills and come up with new ideas which will help one in developing solutions to different problems that may arise.

As the old adage goes: 'if you want to go fast go alone but if you want to go far go with others'. In the study of Information Technology, individuals are usually encouraged to associate with other people so that they would be in a position of gaining experience in the field.

During my interning period some of the memorable moments included: orientation into the company, meeting different Directors who are heads of various departments and employees from different departments and understanding their functions, and also getting to know the company's mission, vision and its core values.

While at NuPEA I had to set my personal objectives as I worked. The first objective was to attain knowledge on how the company works, how it carries out its duties and the reason why it was formed. The other objective was to gain more knowledge in Information Communication Technology through learning and observation; to know how to solve IT related problems in the company hence making employees have an easy time carrying out their day-to-day activities.

This has been my first experience in the corporate world and I did not know what to expect. I would say NuPEA has good employees who are extremely helpful and approachable hence this has made me feel comfortable working with them.

I must confess I am now ready for the industry. NuPEA has taught me more than enough. Through my internship I have gained a lot of knowledge and conducted self-reflection through which I have identified my weaknesses and strengths. So if one is looking for the best internship experience, then NuPEA is the place to be.

AFRICA'S NUCLEAR FACTS AND FIGURES

South Africa is the only African country with fully functioning nuclear reactors, it is also the only independent state in the world to voluntarily end its own nuclear weapons programme, disassembling its weapons in the early 1990's.

South Africa plans to build eight new nuclear power plants totaling up to 9,600 megawatts by 2030 as part of their estimated \$37 billion nuclear expansion program.

According to the World Nuclear Association, countries actively considering nuclear power programs include Nigeria, Ghana, Senegal, Namibia, Sudan, Uganda and Namibia, while countries already developing plans include Nigeria and Kenya.

The Africa Energy Outlook notes that sub-Saharan Africa "includes three of the ten-largest uranium resource-holders in the world," which include Namibia and Niger.

Namibia holds about 8.2 percent of the world's uranium reserves mined from two sites to fuel nuclear power stations around the world.

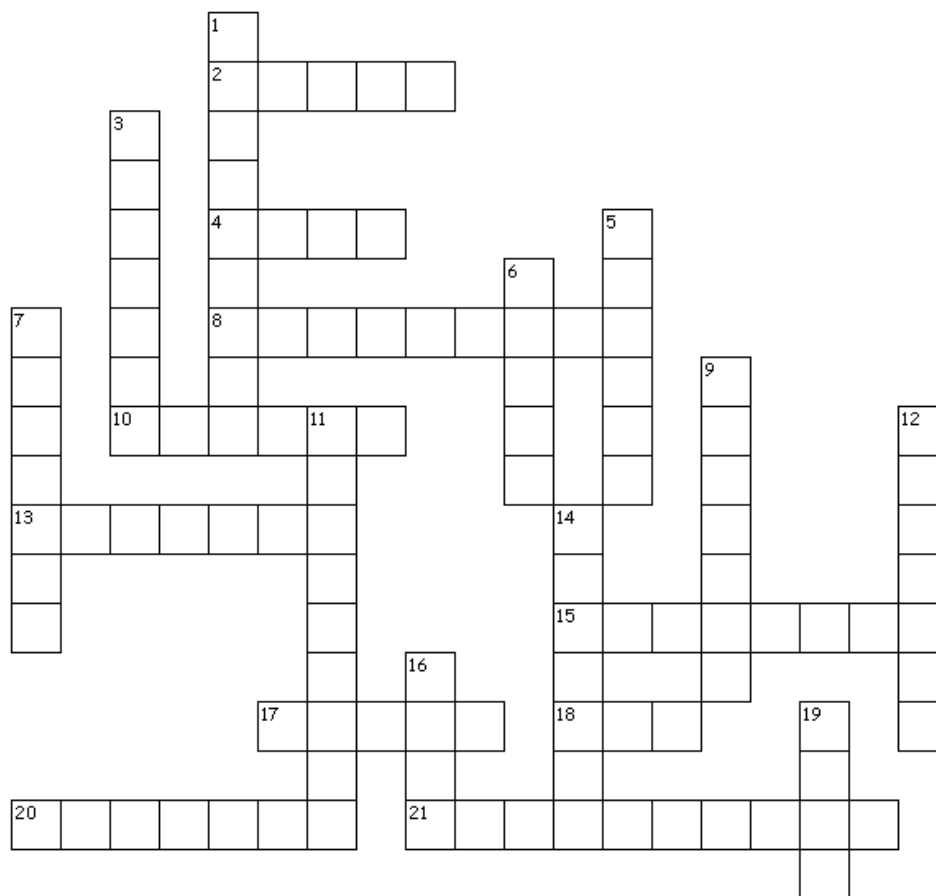
Niger also has two uranium mines which supplies about 7.7 percent of the world's uranium.

Koeberg Nuclear Power Station, Capetown, South Africa



Nuclear Science & Technology

CROSSWORD PUZZLE

**Across**

- 2.** is the least penetrating radiation and can be stopped (or absorbed) by a sheet of paper.
4. Basic unit of a chemical element
8. To expose to some form of radiation
10. Too much ionization of body tissues may cause
13. Element that contain equal numbers of protons but different numbers of neutrons in their nuclei
15. A material that stops ionizing radiation
17. Rate at which energy is transformed?
18. An atomic particle that is electrically charged, either negative or positive
20. Core of an atom
21. Total no of protons and neutrons

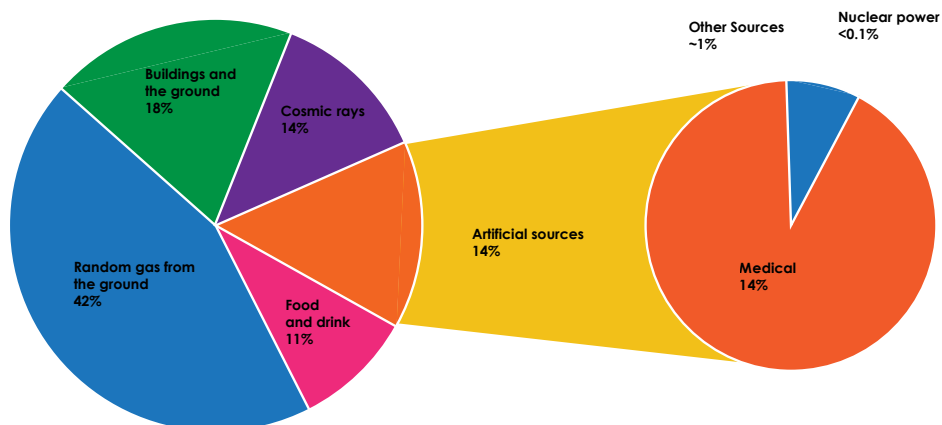
Down

- 1.** Transfer of heat through space
3. Energy at motion
5. Ability to do work
6. Electromagnetic radiation of the shortest wavelength and highest energy
7. Chemical element with symbol Th
9. Splitting of a heavy nucleus into two roughly equal parts
11. Negatively charged particles of atom
12. Headquarters of International Atomic Energy Agency
14. Fuel most widely used to produce nuclear energy
16. Radiation that can be stopped by a thin sheet of aluminum.
19. Term denoting the quantity of radiation or energy absorbed in a specific mass

Answers on Page 25

RADIATION SOURCES AND FACTS

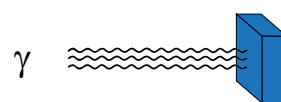
Sources of background radiation



alpha: fast-moving helium nucleus, stopped by air, skin or paper



beta: high energy electron, stopped by aluminium plate or glass



gamma: high energy photons, stopped by, dense material, such as concrete or water

Protection from radiation

Time: Dose is reducing by limiting exposure time.

Distance: The intensity of radiation decreases with distance from its source.

Shielding: Barriers of lead, concrete or water give good protection from penetrating radiation such as gamma rays.

Containment: Radioactive materials are confined to keep them isolated from the environment.

The international commission for radiological protection (ICRP) has developed a system for protection with three basic principles:

Justification: No practice involving exposure to radiation should be adopted unless it produces a net benefit to those exposed or to society generally.

Optimization: Radiation doses and risks should be kept "as low as reasonably achievable" (ALARA), economic and social factors being taken into account.

Limitation: The exposure of individual should be subject to dose or risk limits, above which the radiation risk would be deemed unacceptable.

What is radiation?

Radiation is energy being transmitted through space. Visible light, ultra-violet light transmission signals from TV and radio communications are all forms of radiation that are common in our daily lives. These are all referred to as 'non-ionizing' radiation.

Radiation particularly associated with nuclear medicine and the use of nuclear energy, along with X-rays, is 'ionizing' radiation.

Key points

- Radiation is **easy to detect**, even at extremely low levels.
- Radiation **exists naturally** everywhere at widely varying levels. Places exist where people live with 100 times higher than average background from the ground. A few areas even have levels 1000 times the average.
- Mankind has evolved in a world with strongly differing background radiation without developing a sense to detect it.
- Radiation has always been around and is now **well understood**. It has been used and studied for more than 100 years.

THE INTERVIEW



Brenda Esilaba can apply be described as jack-of-many-trades with a boisterous and bubbly character. Equally at home in the Supply Chain management as with Administrative duties, which have been her two hats over the years she has served at the Nuclear Power and Energy Agency. She shared her insights with *The Fission* magazine's Dennis Nkonge.

Q1. Now you are working for NuPEA, apart from the job, what else do you do, on the sidelines?

I'm a mother of two children Jeanette and Jerry.

Q2. What is the most memorable moment in your life?

With inspiration and guidance from God, I can say that some moments are good, some are nice, and others are worth writing and remembering. Besides, they are called "moments" because they don't linger for long. To me, the memorable moment(s) is that day I held my children in my arms and I knew that my whole meaning to life had changed.

Q3 Which character trait defines you the most?

I am a role model for integrity, generosity, kindness, responsibility and honesty. These are the traits that impact happiness in my life and mutual

coexistence with people around me.

The trait that defines me most, just like the greatest commandment, is LOVE (Mathew 22:36-40).

Q4. So, what's your driving force in life?

Conscience, self-improvement and ambition. I am from a humble background and I know I was born for a purpose, something more than my foundation. As long as I am healthy, I remain relentless to self-improvement because I have determination, the reason to soldier on and a sense of existence even in the most severe and limiting circumstances to improve myself.

Q5. Any hobbies?

Dancing. Over the years, I have come to appreciate that dancing is more of a psychological than a physical exercise. Dancing, has taught me to face challenges head on, because finishing a goal and realizing is the true reward.

Q6. Let us now focus a bit more on your current job at NuPEA. What's the greatest challenge that you have encountered?

During the period I served as a Procurement officer, I have been a best fit since I am concerned about the costs of spending in the organization. As part of my job, NuPEA staff have been very supportive and I strive to remain equal to the challenges I might face. My resolve is to strive, persevere and get things done but if I fail, I pass the challenge to others.

Q7. In your view, would nuclear electricity help Kenya?

Nuclear electricity will truly help Kenya in a big way as the country is currently targeting to be a middle income nation as anticipated in vision 2030. Once we go nuclear, there will be affordable and more reliable energy that will attract investors and hence development of industries and better infrastructures that will ensure service delivery. With climate change as a real and imminent danger, it is essential that the country invest in clean energy.



Q8. If someone asked you to justify why nuclear electricity is a good option for Kenya, what would your response be?

Nuclear electricity is the best option for Kenya, despite the global controversies. Nuclear energy is the backbone providing more than half of electricity needs in developed countries. It is inevitable for the country not to establish a base load power, and nuclear electricity is the surest way to get there.



Q9. Given your illustrious career, what do you consider to be your major achievement?

Staying focused to my career and working in an organization that enables me to demonstrate my proficiency is an achievement, but the major achievement is yet to come because I am still 'updating my software' and God did not create me a 'junk', I still have a lot more to offer.



THE END

NuPEA's GREEN AGENDA AT THE NYABONDO HIGH SCHOOL



Nuclear Power and Energy Agency (NuPEA) Director for Publicity & Advocacy - Basett Buyukah with the Nyabondo High School fraternity during the tree planting exercise.

By Faith Kosgei

On 25th May 2018, Nuclear Power and Energy Agency (NuPEA) visited Nyabondo High School in Kisumu County where they planted 400 tree seedlings with the students.

This is part of NuPEA corporate social responsibility strategy that strongly support environmental conservation coupled with stakeholder participation with a focus on high school students.

NuPEA has previously planted tree seedlings in Machakos and Uasin Gishu Counties as a way of sharing responsibility and inculcating the nurturing culture in environmental protection amongst students.

This is part of the Presidential directive to all parastatals and state departments to include tree planting in their Corporate Social Responsibility activities in a bid to achieve the targeted 10% forest cover by 2022.

Nuclear Career Talk

Besides the tree planting, NuPEA staff also engaged with Nyabondo High school students in a Nuclear Career Talk. NuPEA uses this platform to advise students on career choices, options and opportunities, especially in the nuclear industry.

During the nuclear career talk, NuPEA's team demystified the subject and informed the students more on Kenya's nuclear power program, as well as potential careers in the nuclear energy field.

The session was interactive with participants posing questions to panelists on nuclear-related issues. This enabled NuPEA to shed more light on various concerns raised such as requirements for the various careers



1

in the industry, Safety & Security, Radioactive Waste management and siting of Kenya's Nuclear Power Plants, among others.

Institutions of learning form a critical stakeholder for Kenya's nuclear power programme considering the long lead-time required for a nuclear power programme to be fully implemented. Current high school students will most certainly be the professionals undertaking various aspects of this endeavor, a decade or so from now.

NuPEA will continue the outreach to schools all around Kenya and tree planting as a Corporate Social Responsibility, as a way of giving back to the communities we serve.



2

1. Director for Publicity & Advocacy Mr. Basett Buyukah addressing students at the career talk.

2. Jubilant Nyabondo High School Students during a Nuclear career talk in their school.

3. A student from Nyabondo High School during the Q&A Session.



3

LOCAL INDUSTRIES HAVE A KEY ROLE IN KENYA'S NUCLEAR POWER PROGRAMME



The Multi agency Industrial involvement team led by NuPEA officers at a visit to Doshi group of companies.

By Jonathan Njoroge

During the constructing and operating of a nuclear power plant, many components and services are required. Spare parts, consumable supplies, instrument repair and calibration services are among the many support needs. These supporting activities can be a source of jobs and economic growth for Kenya, however supplying equipment and services to support a nuclear facility requires industrial organizations that can comply with the codes and standards.

It is from this background that in March 2019, Nuclear Power and Energy Agency (NuPEA), hit the ground running by undertaking a research on Kenya's industries capability to supply quality goods and services for the construction of the first 1000Mw Nuclear power plant in Kenya.

The research sought to increase national industries participation or to localize those parts of the industrial involvement activities that national industries can cost effectively achieve the nuclear industry standards. This would only be possible if the national industries operate under rigorous quality assurance programs and comply with strict codes and standards associated with the required goods and services. The research included various industrial visits.

NuPEA carried out research in various industries, such as steel, cement and transport. NuPEA visited over 20 companies in Nairobi and Mombasa. These included: Savannah Cement, Apex steel, Tononoka Steel Company among others.

Some of the assessed areas included the sum of the entire industrial capability required to support a safe and reliable nuclear power programme. This is very important since it will help the country to make well-informed decisions about which parts of industrial involvement need to be developed locally.

From the industrial visits, NuPEA was able to understand some of the challenges that local industries face including: contracting of projects to foreign firms that lock out local industries by importing all project components including labour force, impromptu introduction of new quality standards that will take time for local industries to meet because it might require new machinery, raw materials, training the staff and having the product licenced by the quality assurance body (Kenya Bureau of Standards), high taxes and production cost that affect pricing of good and service, making Kenyan products non- competitive against imports.

The industrial involvement research is very important in Kenya' s nuclear power programme because it establishes the level to which local companies are ready to provide inputs such as steel, cement, piping etc. during operation and construction of Kenya's nuclear power plant.

Industrial Involvement is one of the infrastructure issues required for the establishment of a successful nuclear power program. Even for a single unit, the supply chain for the project will involve hundreds of local companies, several thousands of local employees working directly or indirectly for the project for the basic infrastructure and utility needs of the construction, operation and maintenance.



The team with thier host after the tour of the industry

TRACING NUCLEAR ENERGY'S ROOTS TO GABON



Samples of Oklo donated to Vienna's Natural History Museum. (Photo: Ludovic Ferrière/Natural History Museum)

By Laura Gil

IAEA Office of Public Information and Communication

Physicist Francis Perrin sat at a nuclear fuel-processing plant down in the south of France, thinking to himself: “This cannot be possible.” It was 1972. On the one hand, there was a dark piece of radioactive natural uranium ore, extracted from a mine in Africa. On the other, accepted scientific data about the constant ratio of radioactive uranium in ore.

Examination of this high-grade ore from a mine in Gabon was found to contain a lower proportion of uranium-235 (U-235) — the fissile sort. Only a tiny bit less, but enough to make the researchers sit back and scratch their heads.

We want people to learn about natural radioactivity, to make them aware of the fact that radioactivity is all around us, that it's natural, and that at low levels it's not dangerous. Ludovic Ferrière, Curator of the Rock Collection, Natural History Museum, Vienna, Austria

The physicists' first, logical response to such an unusual ratio of U-235 was that this was not natural uranium. All natural uranium today contains 0.720% of U-235. If you were to extract it from the Earth's crust,

or from rocks from the moon or in meteorites, that's what you would find. But that bit of rock from Oklo contained only 0.717%.

What did this mean? At first, all the physicists could think of was that the uranium ore had gone through artificial fission, i.e. that some of the U-235 isotopes had been forced to split in a nuclear chain reaction. This could explain why the ratio was lower than normal.

But after complementary analyses, Perrin and his peers confirmed that the uranium ore was completely natural. Even more bedazzling, they discovered a footprint of fission products in the ore. The conclusion: the uranium ore was natural and had gone through fission. There was only one possible explanation — the rock was evidence of natural fission that occurred over two billion years ago.

“After more studies, including on-site examinations, they discovered that the uranium ore had gone through fission on its own,” said Ludovic Ferrière, curator of the rock collection at Vienna's Natural History Museum, where a part of the curious rock will be presented to the public in 2019. “There was no other explanation.”

For such a phenomenon to have happened naturally, these uranium deposits in western Equatorial Africa must have had to contain a critical mass of U-235 to start the reaction. Back in those days, they did.

A second contributing factor was that, for a nuclear chain reaction to happen and be maintained, there needed to be a moderator. In this case: water. Without water to slow the neutrons down, controlled fission would not have been possible. The atoms would simply not have split.

“Like in a man-made light-water nuclear reactor, the fission reactions, without anything to slow down the neutrons, to moderate them, simply stop,” said Peter Woods, team leader in charge of uranium production at the IAEA. “The water acted in Oklo as a moderator, absorbing the neutrons, controlling the chain reaction.”

The specific geological context in what today is Gabon also helped. The chemical concentrations of total uranium (including U-235) were high enough, and the individual deposits thick and large enough. And, lastly, Oklo managed to survive the passing of time. Experts suspect there may have been other such natural reactors in the world, but these must have been destroyed by geological processes, eroded away or subducted — or simply not yet found.

“That's what makes it so fascinating: that the circumstances of time, geology, water came together for this to happen at all,” Woods said. “And that it was preserved until today. The detective story has been successfully solved.”

A rock sample in the IAEA's home city

Rock samples from Oklo, some of them recovered during drilling campaigns, are stored in the headquarters of France's nuclear power and renewable energy company Orano. In early 2018, two half split drill-core samples were donated to Vienna's Natural History Museum. The donation was made possible by the financial contribution of Orano and France's Alternative Energies and Atomic Energy Commission (CEA), with the support of the French Permanent Mission to the United Nations and the International Organizations in Vienna. IAEA scientists helped when the sample was delivered to Vienna by monitoring radioactivity levels and facilitating the rock's safe handling.

The two samples emit a radiation of approximately 40 microsieverts per hour if you stand 5 centimetres

away from them, which roughly compares to the amount of cosmic radiation a passenger would receive on an eight-hour flight from Vienna to New York. The museum, which receives 750 000 visitors a year, is used to dealing with radioactive samples since it already displays a number of slightly radioactive rocks and minerals.

“We want people to learn about natural radioactivity, to make them aware of the fact that radioactivity is all around us, that it’s natural and that at low levels it’s not dangerous. Radioactivity is in the floors and walls of our homes, in the food we eat, in the air we breathe, and even in our own body,” said Ferrière. “What better way to explain this than by showing a real sample from Oklo, where nuclear fission occurred naturally billions of years ago?”

The permanent exhibition will show different sources of background radioactivity. Perhaps a world map with the distribution of radioactivity, a radiation detector or Geiger counter or a cloud chamber, will allow visitors to see exposure to natural radiation for themselves.

“Rocks are like books. You can look at the cover and get some basic information, but it’s when you open them that you get the full story,” Ferrière said.

Ludovic Ferrière, curator of the rock collection, holds the Oklo reactor in Vienna’s Natural History Museum. A sample of Oklo will be displayed permanently in the museum as of 2019. (Photo: L. Gil/IAEA)



DEVELOPING THE FIRST EVER FACILITY FOR THE SAFE DISPOSAL OF SPENT FUEL



From the IAEA Bulletin

Nathalie Mikhailova, IAEA Office of Public Information and Communication

The Onkalo disposal facility for spent fuel being constructed in Olkiluoto, Finland, consists of an engineered system of tunnels. Onkalo is also used to characterize the host rock to support safety case development. (Photo: Posiva Oy)

Following several decades of committed implementation of disposal strategies in Finland and Sweden, as well as cooperation in the development of a safe disposal solution based on a Swedish design, the first ever deep geological repository for spent fuel is being constructed in Olkiluoto, Finland. Sweden, along with other countries, is also working towards building such a facility.

After spent fuel is removed from nuclear power reactors, it continues to generate significant heat for several decades. It is therefore placed in water pools or in dry storage facilities to cool down. Storage pools and containers ensure that spent fuel maintains its integrity and no radiation or radioactive materials are re-

leased, thereby protecting people and the environment from exposure. However, spent fuel remains highly radioactive for several thousands of years and needs to be isolated for several hundred thousand years.

One way to dispose of spent fuel — when declared as waste — once the heat has decayed is to bury it in engineered facilities several hundred metres below ground level, in deep geological disposal facilities. The objective is to contain its radioactivity by encapsulating the spent fuel in robust and leak-tight containers and isolating it by burying it. Such facilities consist of a system of tunnels or chambers, built at a site geologically suitable for ensuring the long term safety of the buried material (see [Deep geological disposal facilities](#)).

The facility being built in Finland is based on the 'KBS-3' disposal concept, which was developed by the Swedish Nuclear Fuel and Waste Management Company (SKB), in close cooperation with Posiva, the Finnish company responsible for the disposal of spent nuclear fuel. The KBS-3 method consists of encapsulating spent fuel in corrosion-resistant copper canisters and embedding the canisters in swelling clay inside the repository's tunnels up to 500 metres below ground level.

"Not only are we both opting for the direct disposal of spent fuel, but Finland and Sweden also have similar reactors, which means that we have similar spent fuel. Expanding direct cooperation for various research and development activities made sense for both of us," said Magnus Westerlind, Senior Advisor at the SKB. "For example, we have done basically everything related to the copper canisters as a joint development project."

In both countries, government decisions in the late 1970s and early 1980s led to the introduction of policies requiring the producers of nuclear waste to also be responsible for its management. In Finland, spent fuel from the Loviisa nuclear power plant was transported to the Soviet Union, and later Russia, for reprocessing until 1996. When the Finnish government issued the operating license for the Olkiluoto nuclear power plant in 1978, it requested that the licensee develop a waste management plan, including for spent nuclear fuel, which had to be disposed of in Finland.

In Sweden, power plant owners came together in the late 1970s to form the SKB with a view to jointly manage spent fuel. This initiated research and development activities for the development of a disposal concept, which ultimately led to the KBS-3 method. This concept was selected as an appropriate means of waste disposal in 1983 and has since been developed further. A site for the implementation of this concept has been selected and plans for construction are under way.

"An important element in actually implementing the disposal strategy in practice is the review process, which takes place every three years," said Westerlind. "As part of this process, numerous parties — universities, government agencies, non-governmental organizations and municipalities — are invited to comment on our strategy. This has made a significant contribution to not only the technical review of our programme, but also to making sure that the programme is in line with Swedish policies." Furthermore, extensive work has been done, and is ongoing, to gain and maintain public acceptance for siting and construction of the spent fuel disposal facility, he added.

Constructing the first ever disposal facility in Finland

Before construction of a disposal facility can begin, the company in charge of implementing the concept needs to obtain a construction licence. In Finland, the licence was issued in 2015, marking the first time a construction licence for a geological disposal facility was received anywhere in the world.

The site was chosen following several years of screening a number of potential sites. After surveying the country's land mass based on geological information, Posiva continued site characterization through site-specific studies, which included drilling, to find a geologically suitable environment. During this process, Posiva also started discussions with several municipalities about hosting a facility.

“Social acceptance and social factors play a crucial role in site selection,” said Jussi Heinonen, Director of the Nuclear Waste Regulation and Safeguards Department at Finland's Radiation and Nuclear Safety Authority (STUK). “Social acceptance relates to trust for the implementer, regulator and decision makers. This trust has to be built and maintained.”

Posiva is in the middle of the construction of the ONKALO disposal facility, at a depth of over 400 metres below ground level and is set to begin the excavation of the disposal tunnels soon. The disposal process is planned to start in 2024.

Progress in other countries

In 2011, the SKB submitted its licence application for the construction of a disposal facility in Forsmark, 150 kilometres north of Stockholm, which was reviewed by the Swedish Radiation Safety Authority (SSM) and the Land and Environmental Court. These authorities have since submitted their review statements to the government for a final decision on the licence.

Finland and Sweden are not the only countries making progress in this area. In France, the radioactive waste management agency Andra is currently preparing its licence application. In Canada and Switzerland, national waste management agencies are investigating appropriate sites through site characterization.

THE SCIENCE

Deep geological disposal facilities

Intensive research has identified the suitability of various rock types to host deep geological disposal facilities to isolate radioactive waste. These disposal facilities are constructed in suitable geological formations at a depth of several hundred metres and designed to contain high-level waste for hundreds of thousands of years.

A key characteristic of deep geological disposal facilities is that they provide passive safety, meaning that once the disposal facility has been closed, no further human action is required.

Building these disposal facilities several hundred metres below ground level, at a depth that effectively isolates waste from potential surface perturbations for hundreds of thousands of years, involves placing the waste in a non-dynamic environment, as opposed to a more dynamic, near-surface geological environment, where conditions tend to be less stable.

Nuclear power & reactors worldwide

Location	Nuclear electricity generation, 2018 (billion kWh)	Share of total electricity production, 2018 (%)	Number of operable reactors*	Nuclear generating capacity* (MWe)
Argentina	6.5	4.7	3	1667
Armenia	1.9	25.6	1	376
Belgium	27.3	39.0	7	5943
Brazil	14.8	2.7	2	1896
Bulgaria	15.4	34.7	2	1926
Canada	94.5	14.9	19	13,553
China	277.1	4.2	43	50,900
Czech Rep	28.3	34.5	6	3932
Finland	21.9	32.5	4	2764
France	395.9	71.7	58	63,130
Germany	71.9	11.7	7	9444
Hungary	14.9	50.6	4	1889
India	35.4	3.1	22	6219
Iran	6.3	2.1	1	915
Japan	49.3	6.2	37	36,147
Mexico	13.2	5.3	2	1600
Netherlands	3.3	3.1	1	485
Pakistan	9.3	6.8	5	1355
Romania	10.5	17.2	2	1310
Russia	191.3	17.9	36	29,139
Slovakia	13.8	55.0	4	1816
Slovenia	5.5	35.9	1	696
South Africa	10.6	4.7	2	1830
South Korea	127.1	23.7	24	23,231
Spain	53.4	20.4	7	7121
Sweden	65.9	40.3	8	8376
Switzerland	24.5	33.7	5	3333
Ukraine	79.5	53.0	15	13,107
UK	59.1	17.7	15	8883
USA	808.0	19.3	97	98,699
Total**	2563.0	10.3	446	397,529

*as of 07.06.2019

Sources: World Nuclear Association, IAEA

**The world total includes six reactors on Taiwan with a combined capacity of 3719 MWe, which generated a total of 26.7 billion kWh in 2018, accounting for 11.4% of its electricity generation.

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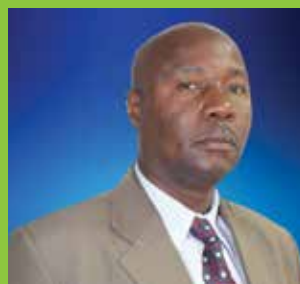
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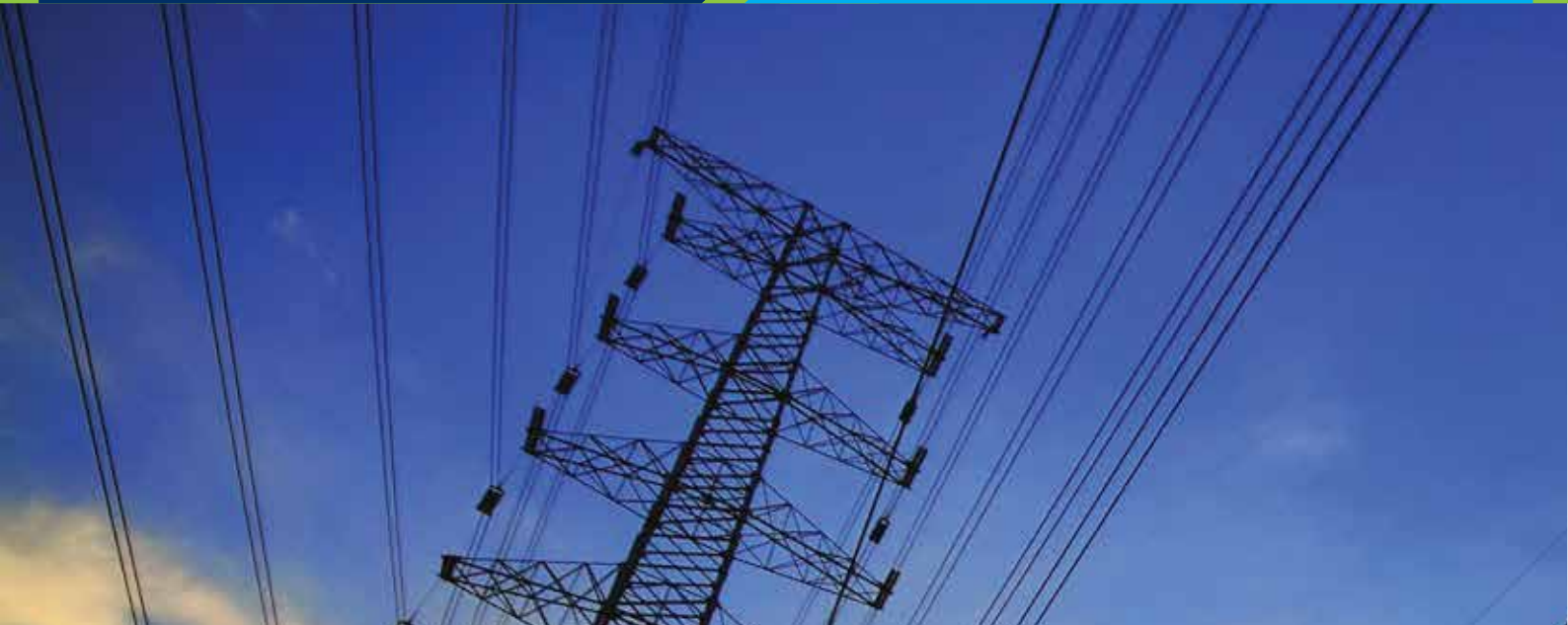
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Mr George Muthemba
Alternate to PS
National Treasury



Nuclear Power and Energy Agency
Kawi House, South C
P.O. Box 26374 00100
Nairobi, Kenya
Tel: + 254 (20) 5138300
Email: info@nuclear.co.ke



@nuclearkenya



Nuclear kenya



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