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P01

Abstract template for “Romania’s Development Plan for present and future types of NPPs”

Condruz Nicolae Ioan

National Commission for Nucler Activities Control

The presentation will focus on the general description regarding the future plans of Romania, which include the building of two new units at Cernavoda NPP and also new types of reactors (SMR).
The need for new plants to be complementary to basic operation of CANDU type plants will be underlined.
It will also describe other aspects about choosing the type of SMR, cooperation with NUSCALE, site selection.

[1] Condruz Nicolae Ioan, National Commission for Nuclear Activities Control

P02

ABSTRACT FOR SUSTAINABLE ENERGY MATRIX SCENARIO IN ARGENTINA WITH MESSAGE

Coppari, Diego Martín [1]

[1] *Strategic Planning Department, National Atomic Energy Commission*

The electricity supply study presented is part of the ARCAL RLA2017 Project "Support for the Formulation of Sustainable Energy Development Plans at the Regional Level - PHASE III". In it, a national case was carried out using the IAEA MESSAGE tool, to evaluate the supply of demand in an energy transition scenario. That demand was first projected with the IAEA MAED model and used as input for the supply study.

For this, the removal of machines was contemplated to reach the highest percentage of decarbonization possible, where the decommissioning of all steam turbines that do not burn natural gas and obsolete combined cycles, as well as diesel engines fed with fuel oil and gas oil, were taken into account. Regarding incorporations, six types of technologies with low or zero GHG emissions factors have been considered, among which "projects" and "candidates" stand out. For future supply, the closing of combined cycles were contemplated as projects, as also the hydroelectric plants. As future candidate technologies: combined cycles and gas turbines fed with natural gas (as bridge fuel in the energy transition), wind farms, photovoltaic solar parks and reservoir hydroelectric power plants. In addition, the nuclear system was contemplated with nuclear power plants and fuel elements, both from existing plants and from future projects and candidates. Nuclear projects contemplated: CAREM-25 prototype of 32 MW, a PWR Hualong of 1150 MW, CAREM COMERCIAL in modules of 120 MW, and PHWR CANDU of 740 MW. Contemplated nuclear candidates: CAREM of 120 MW, from the year 2035 until the end of the period and PWRs in 1000 MW modules from the year 2035 until the end of the period.

Regarding the results, as can be seen in Figure 1, the thermal fossil generation increases towards the end of the period, but this is only 17.6% higher with respect to the base year. In the case of hydro, this is 19.5% higher than the value of 2018, but when observing the values of wind, solar photovoltaic and nuclear, they increase changing the energy matrix.

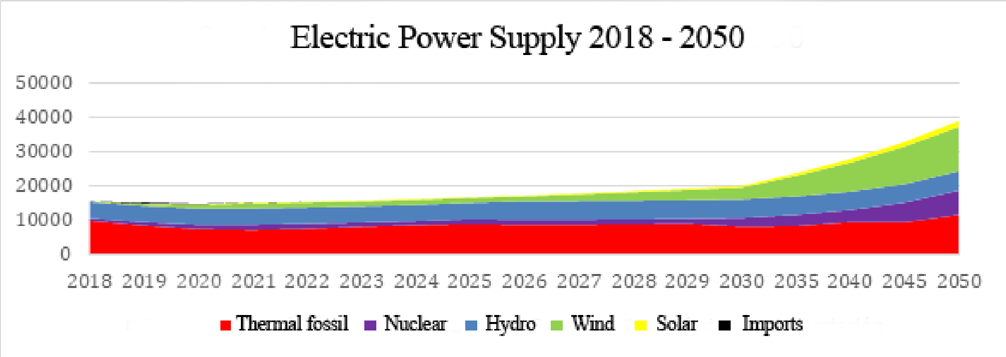

Figure 1 - Electric power supply 2018-2050

Thus, by the year 2050, the following technologies will be incorporated: combined cycle (1.600 MW), gas turbines (2.000 MW), PWR nuclear technology (3.000 MW) and CAREM nuclear technology (1.200 MW) hydroelectric PPs (1.150 MW), wind farms (22.800 MW) and solar parks (7.840 MW). These additions will transform the electricity matrix from a 64% thermal fossil-36% free of CO_2 emissions ratio, to one with a ratio of 30%-70%, respectively.

P03

The possibility of using curium as fractions to nitride fuel in a fast reactor

Tatyana Dikova1[1], Daria Tsvetkova[2], Anna Therehova

[1]National Research Nuclear University MEPhI, Kashirskoe shosse 31, Moscow, Russia, 115409, dikovats@oiate.ru,

[2]National Research Nuclear University MEPhI, Kashirskoe shosse 31, Moscow, Russia, 115409, lyzinadd@oiate.ru

At the present time, the problem of radioactivity of spent nuclear fuel (SNF), which accumulates during the campaign of nuclear reactors, is a sharp concern. The main contribution to the long-term radioactivity of SNF is made by minor actinides. One of the ways to reduce the radioactivity of SNF is the burning of minor actinides in reactors. Curium isotopes are alpha-emitting radionuclides. Curium is a good candidate for burning for a number of reasons detailed in the following sources [1-3].

The purpose of the study is to analyze the effectiveness of the use of curium as fractions to fuel in the RBEC. I chose the Serpent software package to perform the calculations. With the help of which I modeled the active core. In this type of reactor, as in a number of space installations, it is favorable to use nitride fuel with fractions of minor actinides [4]. In the calculation, (U+Pu)N, (U+Pu+Cm)N, (U+Pu+Cm+Zr)N and (U+Cm)N were used as fuel.

The fractions at which the reactor operation is possible were calculated. For (U+Pu+Cm)N fractions were: UN – 0.7; PuN – 0.1 and CmN – 0.15. For (U+Cm)N fuel fractions were: : UN – 0.98; and CmN – 0.02. When considering the graph of the change in the reactivity coefficient, it can be concluded that the considered (U+Pu+Cm)N makes it simpler to control the reactor and increase the proportion of minor actinide loaded into the fuel with fractions. To stabilize the fuel on minor actinides, Zr should be used. Pure curium nitride, as well as (Pu+Cm)N should not be used as the fuel of the RBEC reactor for safety reasons.

However, despite a number of advantages that the studied type of fuel gives, there are a number of disadvantages, such as the plutonium production, the difficulty of manufacturing fuel compositions, etc. In addition, this fuel has a number of characteristics that require additional research.

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P04

Calogena – nuclear for urban heating

S. Ivanovic, J. Bartak, A. Vallée

Driven by the impacts of climate change and the energy crisis, governments and companies – large energy consumers in particular – are increasingly considering nuclear power to produce electricity, heat and hydrogen to transition from fossil fuels. To meet these growing expectations, utilities, research institutions, and hundreds of start-ups worldwide are developing innovative solutions to deploy nuclear energy in a large variety of applications, from micro-reactors through small modular reactors to gigawatt-scale units that will allow to produce clean, safe, affordable, reliable and sustainable energy.

While multiple obstacles remain to be overcome, increasing amounts of public and private capital are oriented towards new nuclear technologies, and policy measures are being adopted to facilitate their faster deployment.

One of the sectors which will inevitably undergo a transition in the coming decades is district heating, as in Europe, around 60% of the heat produced for urban heating comes from fossil energy sources.

Calogena™ offers a solution to solve the challenging task of decarbonising district heating systems. A heat source to power heating networks, the Calogena concept is based on technologies used in pool-type research reactors that are largely deployed around the world.

Calogena's target power is 30 MW_{th}, but a 60 MW_{th} version is possible by using two 30 MW_{th} reactors sharing all their auxiliary systems, including their cooling and fuel storage pools. The reactor is composed of two circuits. The main cooling circuit, integrated in a cylindrical vessel, extracts heat from the core where nuclear fission occurs. It operates in natural circulation, without the use of pumps. This heat is transferred to a secondary intermediate cooling circuit, of equal or higher pressure than the main circuit in order to guarantee that any radioactive pollution cannot spread. This circuit operates in forced circulation using several pumps installed in parallel. It is this intermediate circuit that interfaces with the main heat distribution network through a heat exchanger. Calogena has a robust confinement of limited radioactive inventory (compared to large power reactors), whatever the state of the reactor. Calogena is characterised by a high level of intrinsic safety, small size (low inventory of radioactive material) and low pressures/temperatures.

Calogena's control system is designed to be fully automated based on signals received from the heat network operator. Shutdown and cooling of the reactor do not require the use of an external power source, and no human intervention is necessary or required for safety reasons for several days.

The spent fuel and waste management comply with the standard and proven waste management requirements. The dismantling of Calogena is similar to that of a research reactor of the pool type for which industrial experience exists; in France, for example, the dismantling of Siloé at the CEA site in Grenoble can be cited. Finally, Calogena is conceived to operate for 60 years.

P05

RENEWABLE ENERGY SOURCES: A RELIABLE ALTERNATIVE TO FOSSIL FUELS FOR ENERGY GENERATION IN NIGERIA

[1]Maduka, C.S.; [2]Offurum, J.C.

ABSTRACT

This research work centers on the review of Renewable Energy Sources as an Alternative to fossil Fuels for Energy Generation in Nigeria. Our world today is where there is an increasing demand for energy, to carry out the various activities of life, such as cooking food, generate electricity, for communication and working of industrial mechineries. But Nigeria, as a developing nation depends so much on fossil fuels (from petroleum) for its numerous energy demands. And every day, the automobiles (scattered on its roads) and industrial mechineries produce carbon dioxide that is released to the earth atmosphere, and this has the capacity to stay there for more than one hundred years time. The presence of this gaseous molecule in air increases the warmth of the planet, and it is the main cause the so-called "global warming effect". One sure answer to this problem is to replace the technology that encourages the generation of carbon dioxide with possible alternatives that have comparable or better performance. The present study unveils a number of alternative sources of energy, such as Solar, Wind, Geothermal, Hydro and Biomass sources.

***Keyword**: Renewable Energy, Fossil Fuels, Alternative Energy, Nigerian Nation*

] 1] Nigeria Atomic Energy Commission, Abuja-Nigeria.[

2] Department of Chemical Engineering, Imo State Polytechnic, Omuma-Oru East.

P06

ADOPTING NUCLEAR AND RENEWABLE ENERGY SOURCES TO PRODUCE LOW-CARBON ELECTRICITY IN AFRICA: CASE FOR GHANA

Mark Amoah Nyasapoh [1,2*], Samuel Gyamfi [1], Seth Kofi Debrah [2,3], Hossam Gaber [4], Nana Sarfo Agyemang Derkyi [1]

[1] Department of Renewable Energy Engineering, School of Energy, University of Energy and Natural Resources (UENR), P. O. Box 214. Sunyani, Ghana
[2] Nuclear Power Institute, Ghana Atomic Energy Commission, P. O. Box LG 80, Legon, Accra, Ghana
[3] Department of Nuclear Engineering, School of Nuclear and Allied Sciences, University of Ghana – Legon, P. O. Box AE1. Accra, Ghana
[4] Smart Energy Systems Lab (SESL), and Advanced Plasma Engineering Lab (APEL) Faculty of Energy Systems and Nuclear Science, and Faculty of Engineering and Applied Science Ontario Tech University, Canada

Abstract:
In order to achieve a sustainable and resilient energy supply in a low-carbon environment, African nations need to transition to industrialized economies. This study focuses on Ghana and uses the IAEA MESSAGE model to quantitatively evaluate the socio-economic and environmental effects of nuclear and renewable energy sources as possible additions to the country's energy mix. The research demonstrates that nuclear and renewable energy sources such as solar can offer an affordable and low-carbon energy solution to meet Ghana's national development objectives. The study also suggests that nuclear power can be used in conjunction with renewable energy sources to improve the sustainability and resilience of Ghana's electricity system. The paper concludes that successful national energy planning is crucial to meeting Ghana's increasing energy demand sustainably, and the International Atomic Energy Agency (IAEA) Model for Energy Supply System Alternatives and their General Environmental Impacts (MESSAGE) model can be used to evaluate the socio-economic and environmental effects of nuclear and renewable energy systems in Ghana's energy mix. Thus, the research will help inform the creation of successful national energy strategies that will help Ghana achieve sustainable and reliable low-carbon electricity production.

Keywords: nuclear power, renewable energy, energy planning, low-carbon electricity, IAEA MESSAGE model

P07

Evaluation Of Emerging Reactor Technology Designs-Small Modular Reactors Using KIND-ET

Ruth Achieng Okoth [1], **Eng. Erick Ohaga** [2] **Collins Owino** [3] **and Joe Mburu** [4]

[1]*Civil Engineer, Nuclear Power and Energy Agency, P.O Box 26374-00100 Nairobi, Kenya*
[2]*Electrical Engineer, Nuclear Power and Energy Agency, P.O Box 26374-00100 Nairobi, Kenya*
[3]*Mechanical Engineer, Nuclear Power and Energy Agency, P.O Box 26374-00100 Nairobi, Kenya*
[4]*Industrial Chemist, Nuclear Power and Energy Agency, P.O Box 26374-00100 Nairobi, Kenya*

Recently, new comer countries envisioning to introduce nuclear power into their energy mix are increasingly finding Small Modular Reactors (SMRs) appealing. This is due to the SMRs novel designs interms of scalability, adaptability for smaller grids, modularization, suitability for cogeneration, small plant footprint, site flexibility, and load-following capability.
Introduction of the Nuclear Power in Kenya's Energy mix aims at meeting the national energy policy goals/objectives on ensuring energy security, energy equity, access to affordable energy, and climate change mitigation. Currently, the country has an installed capacity of 3000 Mwe and is planning to have its first nuclear power plant operational by the late 2030's. According to Kenya's national energy master plan, an SMR or a medium-sized conventional nuclear power plant is the most suitable technology. This neccesitates the need to undertake an assessment to determine a suitable reactor design that is commercial available and at an advanced stage for deployment.

In light of this, the Key Indicators for Innovative Nuclear Energy Systems Tool from the Comparative Evaluation of Nuclear Energy Systems Options (CENESCO) under INPRO was adopted to evaluate light-water SMR technology designs. The evaluation criteria, technical and commercial, were based on three high-level objectives, six areas of assessment, and fifteen key indicators. Data/information on SMR technologies was obtained from International Atomic Energy Agency and technology developer publications. The findings present the country with the most favorable SMR technology option.

Keywords: *Small Modular Reactors, INPRO, Energy security, Comparative evaluation, Evaluation criteria.*

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P08

Small modular reactors for sustainable energy development

Milana Ozerina [1]

[1] *Rosatom Technical Academy (Moscow, Russian Federation)*

The global nuclear energy technology market is currently undergoing significant structural changes due to increasing competition in both the power generation and power engineering markets. To achieve the greenhouse gas reduction targets outlined in the Paris Agreement [1], nuclear power must make a significant contribution to the overall energy balance, provided that generation needs to be replaced with hydrocarbons. According to the Sustainable Development Scenario [2] of the International Energy Agency, new nuclear facilities, and ambitious programmes to extend the lifecycle of existing nuclear power plants will be required to achieve these goals.

Globally, policymakers, energy analysts, and the machinery industry, including private sector enterprises, are showing increasing interest in the potential of small modular reactors (SMRs) as a competitive element of low-carbon technologies to be used in future integrated power systems. The SMRs embody hopes for inherent safety, simplification, and standardization properties that can substantially facilitate and make more cost-effective the commissioning of advanced nuclear power plants based on SMRs [3].

Among the drivers of SMRs' development are some of their specific characteristics. They can be deployed gradually to match rising energy demand, resulting in moderate financial costs. SMRs show the prospect of significantly reducing costs through their modular design, which should reduce construction time and costs. SMRs are also considered for several non-electrical applications, like hydrogen production and municipal and industrial heat generation. Some designs may also serve niche markets, for example, by deploying micro-reactors to replace diesel generators on small islands or in remote regions. SMRs are also a good option for replacing existing coal plants worldwide, thereby reducing the carbon footprint. The market expectations for SMRs are also associated with exports to countries with weak energy networks and little experience in the development of nuclear energy, which is possible due to the small size and peculiarities of the passive safety systems.

With carbon price pressure on traditional power, the positive attitude of the public towards the new appearance of nuclear power, and the potentially large volume of construction, competition to acquire a share of the market is already underway around the world. In the coming years, it will be possible to see the implementation of the first projects of low-capacity nuclear power plants and their real economy, which will determine the market size and its possible saving role for the entire global nuclear industry.

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P09

Modeling and optimization of the power system using modular nuclear power plants

Petrus Oleksandr, Kravchenko Vladimir

Odessa National Polytechnic University (ONPU)

The purpose of the scientific study is to analyse data and technical parameters on small modular nuclear reactors in order to determine the most suitable power plants for their synchronization and subsequent integration into the existing power system. Small modular nuclear reactors[1] are modern nuclear reactors with a capacity of up to 300 MW per unit, which is about one third of the generation capacity of traditional nuclear power reactors. SMRs can generate large amounts of low-carbon electricity.

Starting from the second half of 2022, the energy system of Ukraine is in dire need of reorganization and improving the reliability and fault tolerance of its main nodes. SMRs are a logical continuation of traditional nuclear power plants, but they have a number of advantages compared to them: small dimensions, low cost, more flexible reactivity control. Given these facts, their relevance and application in the energy system is extremely acute and relevant. The ultimate goal is to connect critical infrastructure facilities to SMR, specifically water supply and pumping stations, gas compressor stations, hospitals, schools, maternity hospitals, with subsequent connection to a single power system. It is also planned to use SMRs as power balancers during peak consumption hours - morning, evening. Thus replacing traditional coal, solar and gas power plants. The project has relevance and scientific novelty.

Among the models under consideration were RITM-200 reactors (RosAtom)[2], and the project by NuScale Power[3]. The problem of work should include the fact that to date, not a single SMR has been put into mass production and there is no experience in their operation. This complicates the process of building a model, which can certainly affect the accuracy of the data obtained. In this regard, all available data is collected for the purpose of their further processing using the latest generation neural network, which will allow in the future to reduce the percentage of errors in calculations and building a working model. Possible ways to solve the problem should also include the creation of a working draft of the power system for the future integration of SMRs into its composition, after the start of their mass production. This would save time for the implementation of the pilot project.

The role of SMRs for the future energy system of mankind cannot be underestimated, any sustainable economic model demonstrates the same principle - the development of the economy is the development of technologies, and the development of technologies is the development of the energy system. Without the strategic and sustainable development of the energy system, the state cannot claim the sustainable development of the economy and, as a result, all spheres of the national economy.

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Nuclear-renewable hybrid energy system (N-R HES) operating off-grid to supply electricity, heat and hydrogen for industry demand in Brazil

Santos S. Gabrielle [1], Velasquez Carlos E. [1] Lombardi C. Antonella [1]

[1] *(Universidade Federal de Minas Gerais)*

Energy demand has changed since the industrial revolution and utilization of non-renewable fuels has been increasing. As access to energy has risen in the last decade, the high cost of electricity, the CO_2 emissions and the energy security are the main problems in any country around the world. [1] Therefore, it's not safe for nations to rely on few energy sources, as it could become strictly dependent on weather conditions, fuel prices, resources availability, among others. Thus, the ideal energy matrix should be composed of different energy sources to warranty the energy supply. [2] In summary each energy source has its own contribution and positive side. In other words, some of them are flexible, or more environmentally friendly, or more efficient, or cheaper than others. Consequently, the integration of alternative energy sources into the energy mix is the main challenge nowadays.

Currently, nuclear energy is considered an alternative energy source, but it has been used since last century with its ups and downs during the years. On the other hand, renewable energy sources, such as wind, solar, and hydro, are being exhaustively discussed for a carbon free world. However, renewable sources have their limitations due to intermittency and seasonality. Several works are studying the integration of SMR with renewable energy to produce electricity on isolated systems. The operational flexibility and load following ability of SMR make a very important combination to support the integration with renewables, as it is capable to provide the constancy and reliability necessary to cover the gaps left by them. In addition, the N-RHES (Nuclear-renewable hybrid energy system) can provide not only electricity in a reliable way but it can also work for cogeneration purposes. [3]

The goal of this study is to analyse the viability of a N-RHES to supply electricity and cogeneration products for the industrial sector in Brazil. The analysis will be based on an off-grid system, which will be composed of wind, solar and nuclear power plants. The SMR will provide steam and electricity to the industry, meanwhile the solar and wind power plants will supply only electricity. The exceeding electricity and heat generated by the system will be used for hydrogen production. Then, it will be analysed the integration viability of N-RHES in Brazilian industrial market. The analysis aims to compare the viability of electricity prices for the isolate systems using N-RHES and the conventional electricity market. Additionally, another comparison will be performed, between cogeneration products used in industry and conventional fuels.

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P11

Proliferation Resistance Assessment of Fuel Fabrication Facility for PWR-Type 100-MWe Small Modular Reactor Using INPRO Methodology – A Case Study

Juan Carlos Sihotang[1] , **Arief Sasongko Adhi**[1] , **and Refa Artika**[1]

[1] *Research Organization for Nuclear Energy – Indonesia National Research and Innovation Agency Affiliation 1*

Indonesia performs study to develop new and renewable energy technology, including a prototype of commercial nuclear power plant (NPP) for generating electricity with low carbon emissions. Consideration on a small modular reactor (SMR) design is given for deployment in West Kalimantan, Indonesia. To address the sustainability of the deployment, a nuclear energy system assessment (NESA) project is conducted using a case-study of land-based, integrated PWR type of 100 MWe – denoted as SMR1. NESA project on the related nuclear fuel cycle of the corresponding SMR are also conducted, started with fuel fabrication (including reconversion). Assessment are performed in the areas of economics, infrastructure (including physical protection), waste management, proliferation resistance, environment, and safety. The area of proliferation resistance requires a general assessment because neither domestic enrichment nor reprocessing is involved since Indonesia is opting for a once-through cycle. Assessed facilities are combination of existing fuel fabrication facilities in Indonesia, planned/conceptual facilities, and reference facilities - given the limited availability of data of fuel fabrication in the open sources due to its commercial nature. The results confirmed that many proliferation resistance criteria are met to support fuel fabrication facility for of light-water type SMR in Indonesia.

P12

Current Research Activities on Nuclear Energy Sustainability Assessment in Viet Nam

At the global climate change conference COP26 in Glasgow, Viet Nam has committed to phase out coal fuel energy production by the 2040s and then reach net-zero emission target by 2050. These commitments lead to the possibility that Viet Nam may reconsider nuclear power again because of the fact that it can play a crucial role in future energy transition in Viet Nam. Therefore, although the Ninh Thuan nuclear power plant projects have been postponed since November 2016, building capacity for Viet Nam to analyze and evaluate nuclear power deployment scenarios, to support decision making and to systematically assess the sustainability of nuclear energy systems becomes very important and necessary. In this poster, current activities in studying and applying the INPRO methodology and ASENES tools for analyses of nuclear energy systems and scenarios that can be applicable to future introduction of nuclear energy in Viet Nam are presented. The ultimate goals are to provide the policy makers of Viet Nam with sufficient information on nuclear energy sustainability in support of future national energy transition toward net-zero emissions.

P13

Impact of self-focused high power beam on Stimulated Raman Scattering in Collisional magneto-plasma

Keshav Walia

Email: keshavwalia86@gmail.com

Department of Physics, DAV University Jalandhar, Punjab(India)-144012

In the present work, impact of self-focused high power beam on Stimulated Raman Scattering (SRS) in Collisional magnetoplasma is investigated. There is carrier redistribution on account of non-uniform heating causing modification in plasma density profile in a direction perpendicular to pump beam axis. The incident beam, electron plasma wave and back-scattered beam are greatly affected on account of this modification in plasma density. Nonlinear differential equations for beam width parameters of various waves involved in the process are set up and solved numerically by making use of RK4 method. Effect of variation in laser-plasma parameters and externally applied magnetic field on focusing ability of various waves involved in the process and SRS back-reflectivity are also investigated in detail.

Keywords: Self-focusing, Stimulated Raman Scattering, Collisional Plasma, Non-uniform heating.