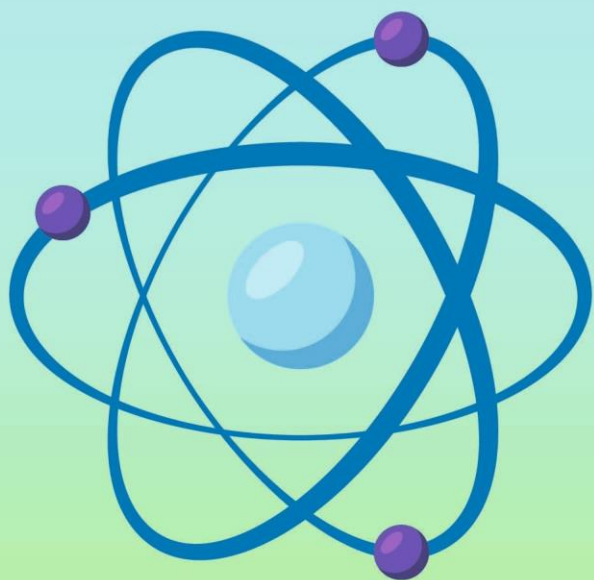




European
Commission

High Level

European
Nuclear
Roundtable



Research and
Innovation

High Level European Nuclear Roundtable

European Commission
Directorate-General for Research and Innovation
Directorate RTD — Directorate C – Clean Planet
Unit C.4 — Euratom Research
Contact Domenico Rossetti di Valdalbero and Cristina Fernandez Ramos
Email Domenico.Rossetti-di-Valdalbero@ec.europa.eu
RTD-PUBLICATIONS@ec.europa.eu
European Commission
B-1049 Brussels

Manuscript completed in July 2021.
2nd edition.

The European Commission shall not be liable for any consequence stemming from the reuse.
The views expressed in this publication are the sole responsibility of the author(s) and do not necessarily reflect the views of the European Commission.

More information on the European Union is available on the internet (<http://europa.eu>).

PDF	ISBN 978-92-76-40316-6	Doi: 10.2777/029878	KI-08-21-206-EN-N
-----	------------------------	---------------------	-------------------

Luxembourg: Publications Office of the European Union, 2021

© European Union, 2021



The reuse policy of European Commission documents is implemented by Commission Decision 2011/833/EU of 12 December 2011 on the reuse of Commission documents (OJ L 330, 14.12.2011, p. 39). Unless otherwise noted, the reuse of this document is authorised under a Creative Commons Attribution 4.0 International (CC-BY 4.0) licence (<https://creativecommons.org/licenses/by/4.0/>). This means that reuse is allowed provided appropriate credit is given and any changes are indicated.

For any use or reproduction of elements that are not owned by the European Union, permission may need to be sought directly from the respective rightholders.

Image credits:

Cover page: © ivector #235536634, #249868181, #251163013, #266009682, #273480523, #362422833, #241215668, #244690530, #245719946, #251163053, #252508849, 2020. © Nikolai Titov #139317295, 2021. Source: Stock.Adobe.com

High Level Nuclear Roundtable

12 May 2021

TABLE OF CONTENTS

FOREWORD	3
MR. MANUEL HEITOR	4
MS. MARIYA GABRIEL	5
MR. BERNARD SALHA.....	7
Mr. YVES DESBAZEILLE.....	8
MS. SATU HELYNEN	10
MR. PHILIPPE STOHR	11
MR. BOHDAN ZRONEK.....	13
MR. JOZEF SOBOLWSKI	14
MR. ROBERTO ADINOLFI	16
MR. HAMID AÏT ABDERRAHIM	17
MS. INGE PAULINI	19
MR. BORIS BRKLJACIC	21
MS. SONYA BORISOVA SERGIEVA	22
MS. ELVIRA ROMERA GUTIÉRREZ	23
WRAP-UP SESSION.....	24
OPERATIONAL CONCLUSIONS	25

FOREWORD

With the European Green Deal, the European Union is setting course to become the first carbon-neutral continent by 2050. The package of energy and climate proposals adopted by the Commission on 14 July 2021 triggers structural transformations to reduce greenhouse gas emissions across economic sectors including energy, industry, transport and built environment. Technological innovation will be needed in order to achieve the target of 55% emission reduction by 2030 compared to 1990.

On 12 May 2021, I convened a high-level European nuclear roundtable with representatives of industry and research organisations. This event was organised in collaboration with the Portuguese Presidency of the EU represented by Minister of Science, Technology and Higher Education, Manuel Heitor, and with MEP Cristian Buşoi, Chair of the European Parliament Committee on Industry, Research and Energy (ITRE). It offered to 12 important nuclear stakeholders the possibility to share their main concerns and to exchange ideas on forward-looking initiatives in the nuclear sector.

This publication reports on their presentations and sheds light on promising technologies in the domain of power generation and beyond: exploiting heat potential for district heating, desalination and decarbonising energy intensive sectors as well as for nuclear medicine. With this roundtable, I wanted to tackle the issue of nuclear safety in existing and future power plants. But I also wanted to address the questions of radiation protection, waste management and non-power applications.

The three keywords emerging from this roundtable conversation were 'Synergies and cross-sectorial fertilisation', 'Innovation' and 'Education and training'.

We need to create and strengthen synergies between nuclear science, energy technologies, medical applications, digital systems, ICT and robotics. It is clear that the Euratom Research should align with recent EU initiatives beyond power generation, like the Europe's Beating Cancer Plan whereby nuclear researchers have to investigate the best ways to protect patients undergoing diagnostics and cancer therapies involving radiation sources.

Another important issue to address is the role of Artificial Intelligence and robotics in the nuclear sector, both in fusion and fission as well as in medical applications. AI and robotics are challenging topics already addressed by the sector (for e.g. 'Digital Twin' for nuclear power plants or remote-handling in ITER) but should be further explored to maintain the highest innovative standards.

When it comes to education and training, we should focus on strengthening access to nuclear infrastructures and facilities. The nexus among industry, academia and R&I community has to be reinforced to foster European talents in the nuclear sector.

The operational conclusions stemming from the roundtable aim at increasing synergies between R&I and nuclear industry in Europe and among Member States. They also make an appeal to attract young talents in the nuclear sector. I am very pleased with the level of engagement and vision expressed during this important dialogue and I look forward to continuing the conversation.

On 2 July, the European Commission adopted the Euratom Research and Training Programme with EUR 300 Million for 2021-2022 for fusion and fission-related topics. We have organised a workshop on AI and robotics in the nuclear sector (16 July 2021). Finally, I expect to participate to the NESTet conference on education and training in the nuclear sector (November 2021) and I will promote the FISA-EURADWASTE conference in close collaboration with the French Presidency of the Council at the beginning of 2022.

The agenda is busy but we go forward with enthusiasm and purpose.

Mariya Gabriel
European Commissioner for Innovation, Research, Culture, Education and Youth

Mr. Manuel Heitor

*Presidency of the Council, Portuguese
Minister of Science, Technology and Higher
Education*



Let me thank Commissioner Mariya Gabriel for organizing this debate at this very unique roundtable. Certainly, we live in unprecedented times, which oblige us to face uncertainty, to face an increasingly risky time that we live on, and the only way, as we know, is to address knowledge.

Nuclear sciences provide the basic foundations of matter and therefore we should emphasize more and more the key role nuclear sciences play in the development of many sectors, from industry to energy, but more and more on looking at the quality of life of our populations.

And I would like to centre in this debate around physical medics, because physical medics has been particularly distributed and developed in an equal shape across Europe. We need to emphasize the role of nuclear sciences to improve the quality of life and therefore, from prevention to care, certainly also to better improve radiation therapies in the European context.

In this sense, the applications are enormous, from dental care to cancer prevention or cancer treatments. But again I would like to emphasize a key role of nuclear sciences so that we can guarantee, for example, a full European network of proton clinics. This can only be developed if we bring together nuclear scientists and nuclear science, in particular those working in particle physics, with cancer hospitals and cancer centres.

Approaching by the end of next decade, this overall idea that every region will have at least one proton clinic for 10 million European citizens, and therefore, throughout Europe, we guarantee a full network of at least 45 proton clinics for European citizens. This should be a collective effort bringing together all of those associated with nuclear science and the national health services.

In Portugal, we are fully engaged - also in collaboration with CERN - to more and more bring attention to nuclear medicine: by training more and more people from medical and nursery schools in the key aspects of nuclear sciences, and to bring together our research community in physics with our clinical practitioners and clinical researchers particularly in the area of cancer. It will be important to bring these also in line with the Cancer Mission and Horizon Europe.

I thank you very much for your commitment, for more and better nuclear sciences but also to give a special role to the applications, to the medical applications, in particular to cancer, and within these, to the development of a fully European network on proton therapy.

Ms. Mariya Gabriel

*European Commissioner for Innovation,
Research, Culture, Education and Youth*



Dear Minister Manuel Heitor,

Dear MEP Cristian Busoi,

Dear representatives of the nuclear industry and R&I community, dear colleagues,

I appreciate the collaboration of the Portuguese Presidency of the EU and the European Parliament in organising this roundtable on the European Nuclear Industry.

It is a pleasure for me to have the possibility to discuss with you the current and future challenges that the nuclear industry and R&I community are facing and will encounter in the coming years. This is an opportunity to deepening our discussion, and think on possible actions to be undertaken in support of the EU policies and for the benefit of the European citizens.

Nuclear power generation currently represents half of the low-carbon electricity in the EU and enables security of supply by ensuring independence from third countries. In such context, nuclear energy can play a significant role in the transition towards a decarbonised Europe.

While many countries in Europe have chosen to continue using nuclear energy as part of their energy mix and some are planning new builds in the next years, some others Member States foresee to phase-out their use of nuclear energy. This sets-up a complex scenario and brings along some challenges which I would like us to discuss today. On one hand, we have a fleet of European reactors characterised by its longevity, posing some safety challenges which need to be addressed. On the other hand, the European nuclear sector has remained during decades at the forefront of technological developments.

I would like to hear from you how Europe can maximise the impact with more cross-fertilization among sectors. Some examples that come to my mind and are already shaping our future like Digitization, Robotics, Artificial Intelligence and the nuclear applications beyond electricity production. Nuclear medicine and space applications are very relevant examples. Therefore, I will be glad to hear from you today, about some of those potential cross-sectoral synergies between nuclear and other technology areas.

In particular, nuclear technologies are strongly embedded in the health sector, e.g. in the diagnosis and treatment of cancer, thus supporting 'Europe's Beating Cancer Plan' promoted by the European Commission. Nuclear science and technology is also a place of innovation for remote handling, new digital applications, robotics or advanced manufacturing. In addition, nuclear applications can be found in space missions, environmental technologies or agriculture. The entire EU scientific community could benefit from the existing knowledge in the nuclear sciences, and we should establish the appropriate channels to facilitate those synergies.

Another important challenge is the need to find new ways to attract scientific and engineering talents.

An ageing workforce, declining student enrolment in scientific disciplines in general, and the resultant risk of losing the accumulated nuclear knowledge is a drawback for the competitiveness of the nuclear sector and, this might lead to weakening EU's position in the global environment.

I would like to have your views on how industry could work closely with academia to build up education and training schemes. How those collaborations should be framed by appealing career perspectives while using all available tools.

Lastly, as the Euratom 2021-2022 work programme will be published on 2nd of July, your insights will no doubt be useful to shape the vision for 2023-2024 work programme, especially for cross-sectoral applications.

I trust that this will be an important step for the Commission, the Member States, and the nuclear industry and R&I towards the optimization of our mutual collaboration. I would like that this high-level roundtable paves the way for a set of future actions to be jointly implemented by the nuclear industry and R&I community, together with the Commission services and the Member States.

Mr. Bernard Salha

*SNETP Governing Board Chair, EDF Group
Chief Technical Officer*



First of all, I would like to thank you Commissioner Gabriel and Portuguese Research Minister Heitor for organizing this high level roundtable. We are quite happy with the close dialogue we have built over decades within the Euratom programme and I would like to thank you and your team in that respect.

Nuclear provides today 26% of the electricity generated in Europe, therefore it can play a big role in the zero carbon energy mix of tomorrow. Nuclear is an innovative and cutting-edge industry: beyond safety, wastes and dismantling management, nuclear can support the development of digital technologies such as Artificial Intelligence (AI); it may also help to improve the knowledge of materials, or to implement new manufacturing techniques as well as to bring many other scientific results into the market.

Nuclear has also the capacity to provide resilience on the electrical grid to complement variable renewable generation. It can provide low and stable zero-carbon electricity prices. It can be a way to generate zero- carbon hydrogen and high-temperature heat with a very low environmental footprint.

For all of the mentioned reasons, cross-fertilization with other technologies such as digital, materials, additive manufacturing techniques, and cross-integration with other energy vectors such as renewables, hydrogen and heat, need to be developed for the global benefit of the EU.

But in spite of all the efforts done up to now, we shall recognize that the budget allocated to the R&D for nuclear, and especially fission, does not allow the European nuclear industry to keep up with its leading role, especially when we compare it with the USA, China or Russia.

The nuclear sector is an extremely innovative field. We have been implementing plenty of innovations over decades to keep the European assets safe, reliable, and competitive. Indeed, the nuclear R&I community is eager to contribute to the European effort, to strengthen the whole European industry by sharing our know-how, our project results, and to initiate new collaborations. Increasing synergies between calls for proposals of different European Research programmes, such as Euratom and Horizon Europe is a way to do it. Because of their high technical content, nuclear use-cases could provide valuable results to several European calls.

Nuclear research is a cutting-edge research. As such, it can contribute to strengthening the education of our young engineers, Bachelors and PhD. who could experience and solve challenges in support of the development of the whole industry in Europe?

We also need to strengthen our research facilities; we need to develop adequate and shared access to them for the academy, research community and industry. Nuclear infrastructures are needed for our industry to keep its position among the worldwide top leaders, having access to best-in-class research and people. The number of jobs and skills at stake is huge: We have today more than 150,00 people working in nuclear R&I. Nuclear industry headcount is more than one million people. Nuclear research and industry is also a domain in which Europe is autonomous and does not rely on Asia or America.

Finally, we believe that cross-cooperation and synergies on European calls strengthened research facilities and enhanced training for young staff could consolidate these numerous jobs and further strengthen them.

Mr. Yves Desbazeille

FORATOM Director General



Nuclear can play a massive role in supporting EU decarbonisation as it provides around one fourth of the electricity in the EU and half of its low carbon electricity.

Many Member States have indeed incorporated nuclear within their National Energy and Climate Plans, both for maintaining their existing plants and for new build plants, some of them even outlining the possibility to use nuclear power for applications beyond electricity such as hydrogen production and industrial process heat.

It is clear, many EU policy objectives could be supported by nuclear in this respect: Energy System Integration, Hydrogen Strategy, and a major one being the new climate law's objective of decarbonisation of 55% by 2030. Long-term operation (LTO) of the existing fleet would play a crucial role in such regard. A recent study from FORATOM has shown that most of the current environmental ambitions of the EU could be achieved thanks to a high LTO scenario across the EU.

To this end, collaboration is key: nuclear industry, R&I community and the European Commission are all crucial parts of the triangle that need to support each other.

In FORATOM we see three key enablers for a successful outcome of this collaboration:

- Investment in nuclear technologies: alignment of public-private strategies with the use of different EU programmes and instruments, thus providing a greater chance for bringing innovation to market and a pipeline of new nuclear projects (Industry/R&I community)
- New industrial alliances in strategic areas of nuclear. Such EU alliances can accelerate activities that would not develop otherwise. We, therefore, fully agree with the recent statement from Directorate Clean Planet in DG Research and Innovation formulating that "Research and innovation are the heart of the new industrial strategy for Europe that can enhance the competitiveness of European industry when translated into the economy".
- Strengthen nuclear contribution in EU initiatives: such as on clean energy competitiveness, the EU Strategic Energy Technologies (SET) plan, and the Action Plan on Synergies between industries. R&I can help the industry to reinvent itself with e.g. digitalisation and supply chain optimization.

At FORATOM, we believe that innovation should be the cornerstone of a forward-looking industry such as nuclear. We are committed to contribute to the EU long term clean energy strategy, but in order to succeed, there are many challenges/ hurdles to overcome: time to market, attracting new talents, developing and implementing demonstrators and pre-industrial infrastructures. By many aspects, our industry does contribute to the EU strategic autonomy, being an ecosystem in itself with many applications across the economy, far beyond power production. For this ecosystem to thrive, we see some strong potential in:

- Developing alliances and platforms gathering communities – for example, an SMR alliance would provide many benefits, but there would be room for other alliances in other domains (medical, etc.)
- Incentivizing a powerful supply chain in harmonizing processes, accompanying its modernization (digitalization, etc.), and increase its value. To make this happen, there's a need to disseminate innovation / modernization across the value chain, down to SMEs which

can play a role of accelerators if well accompanied with technology and financial support as well as high-level skills

- Investing in the future workforce. Our industry already has many initiatives of such kind, with apprentice schemes for technicians and graduate training programmes for new starters, including mobility schemes for staff spending time in different departments and regions.

We believe that the time is right and the mandate is there for industry, the R&I community, and the EC to work together to make sure Europe does not fall behind in skills, standards and technology deployment of key areas of nuclear innovation.

Ms. Satu Helynen

VTT Senior Manager



Nuclear energy has a crucial role in the cost-efficient decarbonisation of Europe where Small Modular Reactors (SMRs) could replace most of the coal and natural gas used for district heating, especially in Northern, Eastern and Central Europe, for desalination in Southern Europe, and satisfy a significant share of process heat and hydrogen demand of industry and transport. Electricity-only-SMRs would be an option of a fast response to overall electrification of the society, also in new nuclear countries, such as Poland and Estonia.

However, the introduction of SMRs to energy sector requires new innovations and increased research input, as well as a lot of investments – and nuclear energy included in the taxonomy of sustainable investments. These types of incentives are extensive in the US, Russia, UK, South Korea and China which presently have their concepts near the market breakthrough. EU should accelerate its SMR R&D&I activities in order to provide European concepts to the opening wide global market. It is not yet too late.

We support strongly SNETP views concerning the idea that Euratom SMR research should be complemented with cross-sector integration. Cross integration of Horizon Europe and Euratom projects will also widen the available talent pool and attract young scientists to nuclear energy sector – including female scientists.

However, cross-sector integration of R&D&I is not in itself neither fast enough nor a final solution for the market uptake of SMRs. In addition, specific activities in all phases of SMRs commercialization path would be necessary. Here are our four suggestions:

- Specific SMR-R&D programme, for example within Horizon Europe and Euratom frame;
- IPCEI type of instrument to combine R&D and industry activities of SMRs;
- Dedicated funding schemes for demonstration plants of different SMR concepts;
- Parallel to all previous: regulatory development by starting a series of pilot licensing processes for SMRs.

Mr. Philippe Stohr

CEA Director of Nuclear Energy



Given the longevity of the EU fleet of reactors, efficient dismantling and decommissioning techniques for Nuclear Power Plants (NPPs) will need to be optimised in the coming years.

The nuclear industry is a highly innovative sector. There are definitively important opportunities for cross-sectoral benefits with shared R&D and innovation with other industrial sectors, and other use cases of nuclear technologies beyond power generation.

Decommissioning and dismantling is a good example to illustrate such possible synergies:

- CEA is deploying a large programme to decommission and dismantle around forty historical facilities (experimental reactor, pilot plant for nuclear fuel cycle, R&D lab, or a waste management facility) which offers a large playing field for innovation and development of new technologies, methods, and state-of-the-art tools;
- Some examples of technologies that provide opportunities for cross-sectoral transfer are: sampling and material characterization, 3D scanning, dedicated cameras or sensors to locate hot spots with radioactive contamination, remote handling and robotics capable of working in severe environments, laser cutting tools, separation or treatment of materials, conditioning of wastes, etc.;
- Answering the complexity of the dismantling projects by preparing in advance the operations: use of digital tools (3D modelling and simulation of installations to optimize dismantling sequences) and virtual environment (preparing and repeating the operations, training the operators with a semi-virtual environment);
- The above-mentioned technologies and industrial experiences offer possible synergies: digital twins and semi-virtual technologies now widely used in various industrial areas, not only in nuclear, for training and optimisation of operations. Other listed technologies can be or are already used, directly or with adaptations, in other industries.

Besides, nuclear, as low carbon energy, can be a primary source for industrial sectors other than power generation if new business models are implemented:

- Small Modular Reactors (SMR) to be interesting multi-purposes tools for the 2050 carbon neutrality agenda. SMR not only as a stand-alone power plant but also allowing for hybrid systems (e.g. 'hydrogen plant' by coupling SMR with high-temperature electrolyser to produce carbon-free hydrogen);
- Heat as a product of SMR, also in cogeneration mode, in order to feed heat networks or industries in need of high temperatures.

As a first conclusion, convergence between nuclear, renewables, and new energy technologies calls for better identification of synergies and cross funding possibilities. One idea to better exploit synergies among sectors could be promoting shared EU R&D programmes between Horizon Europe and Euratom programmes and to open Horizon Europe to projects with the use case in nuclear when R&D results and technologies could be also deployed in other sectors.

Concerning another important priority established by Commission President von der Leyen: the digitalisation of Europe. The EU should pursue ambitious targets concerning the possibilities offered

by digital technologies, artificial intelligence and robotics. Digitalisation of Europe is indeed a very high priority for Europe, but also for nuclear R&D. Robotics and digital technologies are already widely used in the nuclear industry while the nuclear industry has been developing, for a very long time, high fidelity modelling and simulation, using high performance computing. On top of computing capabilities, high-performance computing and high fidelity modelling require: 1) high-level research infrastructures to produce high-quality experimental results to develop and feed the models; and 2) talented and innovative people to operate both R&D infrastructures and execute the computing.

The nuclear sector definitively offers job opportunities for young and talented people in that area. Condition is obviously societal value and future perspectives, such as a long-term vision of the role of nuclear for the 2050 agenda. It is also essential to acknowledge the role of nuclear R&D infrastructures which are ageing in Europe (also worldwide) and need to be renewed: it would be wise to do it in a coordinated manner at the European level and by connecting when possible the several use cases for nuclear sciences.

Concerning the development of nuclear innovative systems, a boost can indeed be expected through disruptive technologies, linked with the use of digital, high-fidelity simulation and new approaches for design and manufacturing. Additive manufacturing and innovative materials 'by design' are two examples of promising areas.

Researches and studies currently on-going on Advanced Modular Reactors can, as well, lead to a breakthrough in the closed fuel cycle strategy. Yet to materialize those expected innovations, some experimental tests are needed in large-scale nuclear R&D facilities, for instance test facilities, mock-ups and prototypes.

To conclude: simulation, digital twins, robotics, or artificial intelligence are essential areas for innovation in nuclear and maintaining European experimental infrastructures for nuclear R&D at best in class level is critical and should be high on the European agenda. Three possible ideas for implementation:

- Organising dedicated technical workshops towards the support of nuclear as a technological solution for decarbonisation and with cross-sectoral benefits. Practically through EU communication and work programmes in complement with Euratom and Horizon Europe;
- Promoting EU coordination through a European Nuclear Infrastructures Forum and by promoting shared access with help of dedicated funding;
- Defining dedicated EU funding mechanisms to secure state-of-the-art nuclear R&D infrastructures today and in long term.

Mr. Bohdan Zronek

CEZ Head of Nuclear Division



Currently, any 'new build' in Europe is a challenge, no matter if one builds renewables, gas or nuclear. Especially at the energy market, which is often unclear and with many and different types of subsidies across EU countries. In order to reach decarbonisation goals, we should keep comparable opportunities to all low carbon sources and keep looking for the best financing models.

Any decision in favour of a nuclear 'new build' is strategic and cannot be taken without determination and control of the government. This does apply not only to large-scale reactors but also to the future build of SMRs. The sensitivity of this decision is highly dependent on signals made not just by the market itself but also by the European Commission vision on the role of nuclear in the carbon-free European power system.

We know that there is strong support for renewables from the EU, we know we have to reach the CO₂ target, but we do not yet have a clear vision from the EU about how nuclear will be integrated into the future energy system and how this vision could be financed.

In this regard, we need new and innovative business models. The cost of money plays a significant part in the nuclear total costs. Therefore, it is crucial to bring the financing costs as low as possible. However, most of the risks are on the State bodies while also the State can control most of the risks itself, thus it seems logical that a significant part of the financing could be provided from the State.

We witness that the nuclear energy was positively assessed by the JRC, so we presume that more assessments and more political pressure from some governments will also arrive. We need a coordinated approach to invest in nuclear if nuclear should be a part of the future carbon-neutral power system.

New and innovative business models have to react to the new roles of nuclear power plants – especially speaking about hydrogen production or heat supply. Until new general investment models will be found and implemented, investments into nuclear new build will be dependent on individual notification of state aid measures to the Commission. As regards CEZ more specifically, we have currently a consensus that an investment aid will be provided in the form of funding (State loan) from the State, as well as operating aid through a power purchase agreement.

Mr. Jozef Sobolwski

NCBJ Director of Nuclear Energy Department



Electricity generation is responsible for about one fourth of greenhouse gas emissions related to global human activities today. Industry, on the one hand, transport on the other, each represent emissions of the same order of magnitude. While decarbonisation of electricity generation is progressing, today almost unnoticed by the public, practically all process heat is produced by fossil fuels.

A new low-carbon process heat source must be available continuously, in large amounts, and at a competitive price. The stability of electricity generation is already a serious issue with increasing fractions of variable renewables, but for process heat production, only nuclear energy can meet these requirements.

Some market heat applications as a function of the process temperature are:

- Below 250°C (20% market): mostly district heating plus desalination and paper production; can be covered by classical Light Water Reactors (LWRs) and new Light Water-Small Modular Reactors (LW-SMRs);
- From 250°C up 1000°C (40% market): dominant chemical and petrochemical industry (550°C); could be covered by Gen IV reactors. The European Nuclear Cogeneration Industrial Initiative (NC2I) and other independent analyses consider only the first step of Very High Temperature Reactors (VHTR) technology, High-Temperature Gas-cooled Reactor HTGR, as a realistic candidate for obtaining the required impact by the 2050s;
- Above 1000°C (40% market): mostly iron and steelmaking and cement; now not available direct heat from the reactor, but hydrogen production using VHTR as an effective thermochemical splitting of water and high-temperature electrolysis.

In 2019 there were worldwide 79 nuclear reactors used for desalination, district heating, or process heat, with 750 reactor-years of experience in these, mostly in Russia and Ukraine. However, for decades barely anything in EU. Some examples of using LWRs for district heating and pulp production outside the EU are:

- LW-SMR in Russia (floating power plants – heat and electricity);
- HTGR-PM in China (260 MWe, 2 HTGR-SMRs) delayed in operation but expected to go in net by 2022;
- Plans in the UK and big plans in the US and Canada.

In addition, I have the pleasure to inform you that today, 12th of May 2021, the Polish government has decided to grant funding for the first phase of a research and technology demonstrator HTGR, consisting in the design and basic concept of the reactor in cooperation with Japan.

We need a much more open EU towards nuclear energy, which does not block pro-nuclear activities. And we need Nuclear R&I integrated with others R&I activities; unfortunately, this was not the case for the last Euratom Work Programme in 2019-2020.

Finally, nuclear fission can further contribute to the decarbonisation goals through innovations in synergy with others:

- Hydrogen generation;
- High-temperature heat;
- Electrical inertia and load following capabilities to support the stability of the electrical grid with a high content of variable renewables sources.

A way of implementing the above could be organizing calls for proposals beyond Euratom Programme, and included in Horizon Europe, which are open to projects with a nuclear content.

Mr. Roberto Adinolfi

ANSALDO Nuclear Board Chairman



Innovation is part 'of the essence' in a High Technology industry such as the nuclear one. It is crucial to make our product more attractive for power companies in making their strategies, and above all to maintain, and even improve the required quality level, which is essential to guarantee the ultimate safety of nuclear installations.

The European Nuclear Supply Chain, notwithstanding the reduced level in new investment projects in the last decades, maintains its ability to innovate. The most appropriate argument for this purpose is the ITER project: it is amazing the number of industries which are successfully participating in this innovative technology program, even from European countries which are not pursuing nuclear power as part of their energy strategies such as Italy. This confirms that where there is a certainty of programmes and long-term perspective, the European industry is ready to invest and innovate.

In terms of technologies, Advanced Manufacturing will be at the forefront of innovation in the mechanical industry, and not only, in the next decades. Nuclear industry shall make the best use of the Innovation potential of Advanced Manufacturing to cope with its three main challenges ahead:

- Integration of Renewable Energy Sources (RES) and Nuclear fostered by the increased Sustainability and Environment awareness in Europe: this new scenario of future electricity grids in the European countries is calling for somehow re-inventing role and features of future nuclear power plants, beyond their historical role to support baseload generation in a centralized network. This challenge will imply research for maximum flexibility of nuclear generation through SMR, as well as for proper energy storage to combine nuclear and RES, including hydrogen production. R&D themes pertinent in this respect are, among others, advanced materials for high temperatures/high pressure and corrosive fluids, surface treatment methods or reduced activation steels.
- Confidence from Financing Community: financial costs represent a large part of the overall investment cost for any new nuclear plant, so licensing certainty, reduced construction costs, design maturity are objectives to be pursued. In this respect, SMR could offer advantages, such as standardization of design, shop manufacturing, limited site works schedule. Advanced Manufacturing, based on computerized control, high precision, information technology, can in this case contribute to production systems capable to grant both the efficiency of mass production and the flexibility of custom manufacturing.
- Proper closure of the life cycle of Nuclear Power Plants (NPPs), up to dismantling and final disposal of all waste streams: the confidence of the public in nuclear power as a fully sustainable form of energy is strictly linked to reassurance, through actual projects, about waste management. While valid solutions already exist and can be implemented, a continuous R&D effort to optimize both waste production and waste disposal is required: advanced materials for waste encapsulation, ability to burn Minor Actinides through Accelerator Driven Systems (such as MYRRHA), reduced activation steels are some of the R&D expected contributions to this purpose.

Mr. Hamid Aït Abderrahim

SCK-CEN Deputy-Director General



First of all, I would like to thank Commissioner Gabriel and Research Minister Heitor for this invitation, as well as the Commission staff, for the organization of this High-level European Nuclear Industry Roundtable'. This allows the various stakeholders from Industry, R&D&I organizations and academia active in the research and innovation fields covered by the Euratom Horizon Europe framework programme, stressing the priorities to be considered in the coming work programmes that would allow nuclear fission to contribute to the goals set forward at the EU level. Some of those goals are linked with the European Green Deal, CO₂ neutrality, security of energy supply, combat against cancer, digitalization and numerical revolution by answering the European citizen concerns through Research, Innovation, and Education & Training of new generations of scientists & engineers in our fields of expertise.

Nuclear technology is based on a high-tech network of industries driven by innovation, R&D and innovation centres and organizations as well as academia. From the middle of the last century, pioneering was and is still driving this sector. It is also the case when it comes to circular economy and recycling of its residues.

Indeed, from the very beginning of nuclear fission technology, the concern of achieving the sustainability and long-term use of nuclear fission energy was based on closing the fuel cycle hence allowing:

- Through recycling the recuperated uranium and plutonium from the treatment of the spent nuclear fuel to extract 50 to 100 times more energy from the same quantity of uranium ore (reducing also the ecological footprint of the mining);
- Through treating part of the high-level waste (the minor actinides) by partitioning & transmutation (P&T) that will be impacting the ecological footprint of the geological disposal by a factor of 4 to 8 and reducing the burden time associated with the radiotoxicity hazard to a few hundred years leaving then geological time scales to human ones.

I wanted to highlight this research field for two main reasons:

- 1) The importance of these innovation fields for nuclear fission that will be leading to more efficient use of nuclear energy and meeting various criteria stressed by the JRC analysis of nuclear energy towards the taxonomy criteria;
- 2) The important role played by the Euratom Framework programme since FP5 in streamlining and fostering the national programs related to P&T.

This has allowed the European stakeholders together with DG Research and Innovation to develop the European vision for preparing the industrial deployment of closing the fuel cycle and addressing the minor actinides via P&T. This European vision called 'The four Building Blocks Strategy for Industrial deployment of P&T' is an attempt to respond to the concerns of EU citizens about the long-term management of the spent nuclear fuel and high-level waste. And this topic is of interest for all of the EU Member States regardless of their specific national energy policy and the role considered for nuclear fission energy in their energy mix. It is also the reason why my country, Belgium, has supported the realization of the MYRRHA experimental Accelerator Driven System contributing to block 3 in the logic of the 'European Four Building Strategy'.

Another aspect of paramount importance to be also addressed, is the role of research infrastructures (RIs), more, in particular, those large RIs which are key elements for the Education and Training of the new generations of scientists and engineers in the nuclear field. Access and availability to them should be guaranteed and supported by EU Research Programmes for the benefit of the future generation of nuclear scientists.

The multi-purpose research facilities already mentioned in the SNETP Research & Innovation Agenda and evaluated through the ESFRI programme (such as MYRRHA and others) are also key elements for the support for the nuclear medicine field as stated in the SAMIRA concerted action.

Ms. Inge Paulini

Federal office for Radioprotection (BfS) President



I would like to thank Commissioner Gabriel and Minister Heitor for their invitation.

I am representing the German Federal Office for Radiation Protection. To my knowledge it is the only institution in Europe that has the tasks of performing research, measurements, and monitoring, and also to inform politics as well as the general public, in all fields of radiation (ionizing as well as non-ionizing and optical radiation) – always with the goal of protecting human and environmental health and wellbeing.

In addition, BfS coordinated the CONCERT-European Joint Programme for the Integration of Radiation Protection Research under Horizon 2020 from 2016 to 2020. The programme contributed to sustainable integration of European and national research programmes in radiation protection and is a great example of how to make better use of public research and development resources. Generally, joint research efforts in key areas and bundling, and cross-linking of expertise contribute to tackling common European challenges in radiation protection more effectively.

We therefore welcome and support the prospective further development of the programme under Horizon Europe as European Partnership for Research in Radiation Protection and Detection of Ionising Radiation. It will continue the integration process throughout Europe and will ensure prudent use of the available financial resources.

Radiation protection is a very broad field and multidisciplinary in science – it must be tailored to societal needs and make full use of newly gained knowledge in all disciplines of life sciences and humanities. As German Federal Office for Radiation Protection, we acknowledge our responsibility and overlook a broad range of issues related to our allocated function.

Coming from this background, I am convinced that Radiation research is much more than nuclear physics – radiation protection and research in this field are essential and elementary for an innovative, safe, and secure future and the health of European citizens.

I would like to highlight the health and medical field as an example:

Medical progress has been substantial in the past and this will most probably continue, especially when it comes to combatting cancer. This is due to fast and substantial developments in diagnosis and therapy – both of which often rely on the use of radiation, mostly ionizing radiation.

But we know that ionizing radiation is a threat to human health. Therefore, this progress and the increased use of these modern measures and tools in the medical and health sector could come with drawbacks. In order to further use and possibly even extend the use of medical uses of radiation, we need to deal with their unintended potentially negative side effects. We need to carefully balance the pros and cons of these uses. Therefore, medical radiation protection is crucial for the health and the safety of patients and for the health and the safety of medical workers. In conclusion, for the health of European citizens it is essential that medical progress is always linked to a careful and thorough risk-benefit analysis and extensive radiation protection research.

Radiation research must be considered right from the beginning when developing new technologies or treatments or medical uses. This also holds true for other sectors, of course, for example for selected industrial processes. That means: Radiation research and radiation protection research are

essential for future technologies and technological progress. Radiation research enables technical progress on one side but is also essential for risk assessment and the development of national and international rules, standards, and recommendations for high-level health protection on the other side. Radiation research helps to ensure that new applications and technical progress will not come at the expense of health.

There are (still) many more open questions, here I name just a few of them:

Understanding of dose and dose-rate relationship for cancer, non-cancer effects, and characterisation of radiosensitivity and radiosusceptibility in humans and ecosystems;

Individual susceptibility to radiation and different doses;

Improvement of health risk assessment associated with low dose/dose rate radiation;

Reducing uncertainties in human and ecosystem radiological risk assessment and management in nuclear emergencies and existing exposure situations, including NORM.

Therefore, we need to maintain skills and competencies – nationally and internationally. We need to do this in research as well as in education. We need to foster interdisciplinary work. But maintaining is not enough – we need to build up expertise and support radiation research significantly. The same holds true for research infrastructure, since it is the foundation for excellent research. Further, it is also necessary to attract young scientists. All this should be taken into account in the preparation of coming European research programmes.

We have very good reasons for building a strong European research infrastructures landscape. Because networking, bundling and cross-linking of existing expertise will allow further development and strengthening of competencies. This is why we need Europe-wide cooperation. We need diversity and diverse perspectives in funding: Europe-wide projects such as CONCERT (and its successor - the planned European Partnership for Research in Radiation Protection) and RadoNorm are the future.

Mr. Boris Brkljacic

EURAMED President-Elect



First of all, I would like to sincerely thank the Commissioner, Ms. Mariya Gabriel, for the kind invitation of EURAMED to participate in this roundtable.

The European Alliance for Medical Radiation Protection Research (EURAMED) was formally established in autumn 2017 as the platform for radiation protection research in the medical field. EURAMED fully supports the integrated approach to European radiation protection research that was further developed successfully through the CONCERT project and more recently through a memorandum of understanding establishing MEENAS.

EURAMED considers of the utmost importance that the research and innovation activities in medical applications of ionizing radiation are driven by the clinical needs in disease diagnosis and treatment rather than by the applicability of existing radiation sources in medicine. This is an important paradigm shift that needs to be achieved in order to ensure technology transfer and application in the clinic and to ensure clinical, societal and economic impact. New medical technology using ionizing radiation needs to be patient-centred and validated, which is not trivial and time consuming due to inter-patient variability. Its use must be harmonized throughout Europe. Patient-tailored procedures in both diagnosis and therapy nowadays allow real personalized radiation medicine, yet the interactions between radiation and new treatment modalities (e.g. gene therapy, immune therapy, nano-medicine) need to be understood and require research, especially regarding potential toxic effects on normal tissues.

The rapid advances in the development of medical applications of ionizing radiation are more and more complex and increasingly rely on AI and computer-based decision support systems. The digital technologies (electronic patient records, large databases on population data, AI-based approaches for the optimisation of procedures and for determining effective therapies) create many opportunities for beneficial use of ionising radiation in medicine, but also raise some ethical and data protection issues that need to be addressed. There is a huge potential for collaboration of medical radiation protection research with the European health and digital programmes, which should be fostered by all stakeholders involved, including the European Commission.

As EURAMED we focus on identifying and addressing research needs in medical radiation application:

- To ensure high quality and safety to our patients suffering from cancer (see also SAMIRA and Europe's Beating Cancer Plan), but also other diseases;
- To foster innovation in medical imaging and radiation therapy;
- To support a stable supply of medical radioisotopes.

An additional challenge is the need to step up education and training in the use of novel medical applications using ionizing radiation and related radiation protection to ensure their safe use. We are also still facing challenges implementing the Euratom Basic Safety Standards Directive. Improvement is needed in particular in the areas of justification, optimisation as well as clinical audit. The development of medical applications using ionizing radiation relies on strong expertise in the fields of dosimetry and radiation biology, making close collaboration between industry and academia a must in order to strengthen Europe's leading role in the medical equipment and technology industry.

Ms. Sonya Borisova Sergieva

Bulgarian Medical Academy



I would like to thank Commissioner Gabriel and Minister Heitor for their kind invitation to attend this high-level European nuclear roundtable.

The quality of patient care during the diagnostic and therapeutic procedures by applying various radionuclides depends on three main factors, concerning the qualification and professional expertise of working key nuclear medicine professionals:

- The first factor is the quality of production and radiolabelling of the used tracers in Nuclear Medicine. That is why the education and qualification of radiochemists and radio pharmacists are extremely important;
- The second factor is quality assurance and quality control of the technical equipment - mainly hybrid cameras / SPECT-CT, PET-CT and CT-MRT / and radiation protection of the staff and the patients. For these reasons, education and training of medical physicists are extremely important.
- The third factor concerns the doctors and in particular the education and training in nuclear medicine.

These three factors show that educational programmes in these three directions are crucial: starting from student programs in the university to continue as a postgraduate scientific and practical training to accumulate nuclear knowledge and expertise. Industry investment in nuclear education, clinical practice, and infrastructures are all very necessary.

Future promising approaches to developing these educational and scientific programmes in nuclear medicine, mainly used in the management of oncological diseases, lay in the creation of a science base and infrastructure, the application of artificial intelligence and robotics and the implementation of research and scientific programs.

Based on the results published in recent years in the scientific literature, it can be concluded that modern nuclear medicine diagnostic and therapeutic methods have a huge contribution to personalized treatment of cancer. The advanced high-tech multimodal SPECT-CT and PET-CT devices with the ability to administer new, specific radiopharmaceuticals for a specific malignancy, both for diagnostic purposes and subsequent therapeutic application, represent a qualitatively new stage in the treatment approach in many solid tumours and haematological neoplasia, which leads to the development of new standards and strategies in the world oncological and onco-hematological practice.

Ms. Elvira Romera Gutiérrez

*Commissioner at the Spanish Nuclear Safety Council
Professor at University of Granada*



The general public lacks often the necessary sound, comprehensive knowledge of subjects related to nuclear and radiation safety, which will be the basis to influence their perception of the radiation risk associated with nuclear energy, radioactive waste, and the use of radiation sources. At the same time, civil society, as well as other stakeholders, expect to have fair and reasonable opportunities to give their views and to influence regulatory decision-making processes.

In parallel, regulatory institutions have the responsibility to inform the public and other interested parties, including governmental authorities and professional and scientific bodies, about radiation risks and regulatory issues. At the international level, the IAEA is the body in charge of this responsibility.

In my country, the Spanish Nuclear Safety Council (CSN) which is the nuclear safety and radiation protection authority, through its safety standards and guidance documents, develops communication and consultation strategies that foster openness and transparency.

Some of the actions that the Spanish Nuclear Safety Council is promoting in order to disseminate sound and scientifically-based information to the general public could be potentially used in a European context. A few examples are:

- Training activities aimed at communication professionals. They can comprise basic concepts on nuclear safety and radiation protection;
- Training courses for secondary or high school teaching staff;
- The use of social networks (both Twitter and LinkedIn) for the dissemination of CSN news, activities, and grants is encouraged;
- Active dissemination of the link to the virtual visit of the Institution's Information Centre through e-mail and social networks, as well as encouraging on-site visits to the aforementioned centre;
- Development and broadcasting of informative videos through the institutional website;
- A more engaging language is adopted in press releases while maintaining technical pertinence and accuracy ;
- Continuous review and update of institutional dissemination publication.



Ms. Mariya Gabriel

*European Commissioner for Innovation,
Research, Culture, Education and Youth*



Mr. Cristian Busoi

*Member of the European Parliament,
Chair of the Committee on Industry,
Research and Energy*

Wrap-up session

We have had an interesting, fruitful exchange about the challenges faced by the nuclear industry and R&I community in Europe

As you might be aware, we are finalizing the Euratom Research Work Programme for 2021-2022 that will be adopted on 2 July 2021. This Work Programme was approved by the 27 Member States at the last Programme Committee on the 3rd of May.

EUR 100 million will be devoted to Fission-related Euratom research priorities in 2021-2022 including support to nuclear safety, non-power applications of ionising radiation, socio-economic aspects of nuclear energy, and closer to the market applications of nuclear technologies in various areas.

The set-up of a Partnership in radiation protection and medical applications is also foreseen, aiming at establishing synergies with the Horizon Europe's Health cluster and contributing to the Commission's 'Europe's Beating Cancer Plan' and 'Mission on Cancer'.

In addition, nuclear scientists will be eligible to participate in the Marie Skłodowska Curie calls for Postdoctoral Fellowships from 2021.

This high-level roundtable with the nuclear R&I stakeholders has therefore given us another opportunity to co-create the future Euratom R&I work programmes together. And thanks to your inputs today, we have collected some valuable insights for the preparation of the Euratom Research Work Programme for the period 2023-2024. This roundtable discussion should help us to optimize the collaboration among the Commission, Member States, industrial and research actors.

Finally, our mutual dialogue, should stimulate the cross-sectoral synergies between nuclear and other sectors, thus promoting innovation, boosting the EU economy, and creating high-qualified jobs.

The interactions between nuclear and non-nuclear fields, and programmes should be boosted. Nuclear medicine, research infrastructures, artificial intelligence, and robotics are typical examples to be further explored. On 16 July 2021, we will organize a workshop on the use of artificial intelligence and robotics in the nuclear sector.

We take good note of your suggestions and recommendations. We will ensure to align them with our European policies.

OPERATIONAL CONCLUSIONS

Nuclear science and technologies supporting EU innovative applications for health, digital and green revolutions

Following this high-level nuclear roundtable conveyed by European Commissioner Mariya Gabriel and Minister Manuel Heitor on 12 May 2021, the topics below could be further developed between Member States, nuclear industry and R&I community in complement to the Strategic Energy Technology Plan and Europe's Beating Cancer Plan.

1. Research and Innovation

Cross-sectors fertilization between nuclear science, energy technologies, medical applications, digital systems, ICT, and robotics:

- For industrial, cross-cutting and medical R&D, increase opportunities of synergies between calls for proposals of Euratom Research, Horizon Europe and Digital Europe Programmes by mapping out the opportunities of interactions between programmes
- In line with the Europe's Beating Cancer Plan, the Euratom Programme will support research on the protection of patients benefiting from diagnostic and cancer therapies involving radiation sources. The European Partnership on Radiation Protection will be launched in 2021-2022 as well as a new project on safe use and reliable supply of medical radionuclides.
- The current Euratom coordination action on nuclear medicine is generating a roadmap for R&I in medical applications using ionising radiation. A follow-up coordination action may be launched in 2023-2024 to test the implementation of these synergies between Euratom, Horizon Europe (Health) and SAMIRA (cf. 'European radioisotope valley').
- Showcase HE and Euratom project results in cross-cutting instruments like 'Missions' and 'Partnerships' starting with the Cancer Mission.
- Enable sharing project results between Euratom, Horizon Europe, cross-cutting collaborations and Digital Europe programmes through cross-cutting collaborations beyond power generation.
- A forward-looking workshop will be organized in 2021 by the Commission on Nuclear, Artificial Intelligence and Robotics.
- Appropriate focussed action(s) or Topics to be launched in the Euratom WP 2023-24 on Artificial Intelligence and Robotics.

2. Research Infrastructures, Education and Training

Strengthen access to and capabilities of priority facilities, which are required during the next 10 to 20 years according to the key topics (nuclear safety, nuclear waste management and dismantling, advanced reactor systems including SMRs). There is a need for a European programme with legal and financial instruments to develop such infrastructures and enable suitable access for industry, academia and R&I community. The European nuclear industry will continue to need around 120.000 employees. Maintaining the workforce in the long term is crucial for the European nuclear leadership.

- Consolidate the education and training activities at the European level based on the amount and type of nuclear skills needed in the long term, and enhancing the collaboration between academia and industry on the curricula and sustainability of the programmes, including for cross-sectoral research cooperation and mobility of nuclear researchers/employees across Europe. The Euratom WP 2021-2022 Topic entitled 'Towards a European nuclear competence area' is a good basis.

- Promote the transfer of knowledge between nuclear and other industries, and applications through enhanced collaboration, as well as the dissemination of Euratom research results towards young students; consolidating the field of nuclear education and training in the EU by building upon previously developed activities e.g. the European Nuclear Education Network (ENEN) and reaping the opportunities from the European Nuclear Society, and in particular the NESTet conference in November 2021.

Getting in touch with the EU

IN PERSON

All over the European Union there are hundreds of Europe Direct information centres.

You can find the address of the centre nearest you at: https://europa.eu/european-union/contact_en

ON THE PHONE OR BY EMAIL

Europe Direct is a service that answers your questions about the European Union.

You can contact this service:

- by freephone: 00 800 6 7 8 9 10 11 (certain operators may charge for these calls),
- at the following standard number: +32 22999696, or
- by email via: https://europa.eu/european-union/contact_en

Finding information about the EU

ONLINE

Information about the European Union in all the official languages of the EU is available on the Europa website at: https://europa.eu/european-union/index_en

EU PUBLICATIONS

You can download or order free and priced EU publications from:

<https://op.europa.eu/en/publications>. Multiple copies of free publications may be obtained by contacting Europe Direct or your local information centre (see https://europa.eu/european-union/contact_en)

EU LAW AND RELATED DOCUMENTS

For access to legal information from the EU, including all EU law since 1952 in all the official language versions, go to EUR-Lex at: <http://eur-lex.europa.eu>

OPEN DATA FROM THE EU

The EU Open Data Portal (<http://data.europa.eu/euodp/en>) provides access to datasets from the EU. Data can be downloaded and reused for free, for both commercial and non-commercial purposes.

The high-level nuclear roundtable was organised by Commissioner Gabriel in collaboration with the Portuguese Presidency of the EU and the European Parliament. It aimed at exploring promising technologies, at increasing synergies between the R&I and nuclear industry in Europe, and especially at attracting young talents in the nuclear sector. This high-level roundtable represented an opportunity to co-create the future Euratom R&I work programmes and to optimise the collaboration among the Commission, Member States, industrial and research actors. It is a first step to encourage interactions between nuclear and non-nuclear fields as well as to develop cross-sectoral synergies for promoting innovation, boosting the EU economy and creating high-qualified jobs.

Research and Innovation policy

