

# **S**ummary Report of the 16th Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation (16IEMPT)

24-27 October 2023,  
Boulogne-Billancourt, France



**NUCLEAR ENERGY AGENCY  
NUCLEAR SCIENCE COMMITTEE**

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## *Foreword*

Efforts to enhance the safety, sustainability and economic efficiency of nuclear energy are driving international research into advanced nuclear fuel cycles. A key component of these efforts is partitioning and transmutation (P&T), a technology that seeks to reduce the volume, heat generation and long-term radiotoxicity of nuclear waste. By incorporating P&T strategies into advanced fuel cycles, the management of nuclear waste can be optimised, addressing technical, economic and societal challenges.

Since 1990, the Nuclear Energy Agency (NEA) has been organising a series of information exchange meetings, providing an essential platform for experts to present and discuss the latest progress in this evolving field. The previous meetings were held in Mito (Japan) in 1990, Argonne National Laboratory (ANL) (United States) in 1992, Cadarache (France) in 1994, Mito (Japan) in 1996, Mol (Belgium) in 1998, Madrid (Spain) in 2000, Jeju (Korea) in 2002, Las Vegas (United States) in 2004, Nîmes (France) in 2006, Mito (Japan) in 2008, San Francisco (United States) in 2010, Prague (Czechia) in 2012, Seoul (Korea) in 2014, San Diego (United States) in 2016, and Manchester (United Kingdom) in 2018. These meetings have been supported by the European Commission (EC), the International Atomic Energy Agency (IAEA) and local hosting institutions.

The 16<sup>th</sup> Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation (16 IEMPT) was held at the NEA headquarters in Boulogne-Billancourt, France, from 24 to 27 October 2023, and was organised in co-operation with the IAEA. It brought together experts from various sectors and was supported by international organisations and key partners such as the EU-funded Horizon-2020 Partitioning And Transmuter Research Initiative in a Collaborative Innovation Action (PATRICIA) Project, the French Alternative Energies and Atomic Energy Commission (CEA), the Multi-purpose hYbrid Research Reactor for High-tech Applications (MYRRHA) Project, and the Japan Atomic Energy Agency (JAEA). The meeting included a plenary session on national and international programmes, two special panel sessions, as well as technical sessions and a poster session that covered a wide range of topics related to P&T and advanced fuel cycles. These meetings are part of the NEA's ongoing efforts to advance knowledge and innovation in nuclear fuel cycle technologies.

This summary report presents the key points and conclusions from all the plenary and technical sessions. The views expressed in these contributions are those of the authors and do not necessarily reflect the positions of the NEA or its member countries.

## *Acknowledgements*

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Special thanks are extended to key supporters, including the EU-funded Horizon-2020 PATRICIA Project, CEA, the MYRRHA Project and the JAEA. Appreciation is extended to the Scientific Advisory Committee for their dedication to organising the workshop and reviewing the abstracts. The NEA is also grateful for the continued support of the IAEA.



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## *List of abbreviations and acronyms*

ADS	Accelerator-driven systems
AmSel	Americium selective separation
ANL	Argonne National Laboratory (United States)
BARC	Bhabha Atomic Research Centre (India)
CALMIX	Combined Air Lifting and Mixing
CEA	Commissariat à l'énergie atomique et aux énergies alternatives (Alternative Energies and Atomic Energy Commission, France)
CNL	Canadian Nuclear Laboratories
EC	European Commission
CHON	Carbon (C), Hydrogen (H), Oxygen (O), and Nitrogen (N)
CIEMAT	The Centre for Energy, Environmental and Technological Research (Spain)
COFs	Covalent organic frameworks
CRIEPI	Central Research Institute for Electric Power Industry (Japan)
EGFRW	Expert Group on Fuel Recycling and Waste Technology (NEA WPEC)
EBR	Experimental breeder reactor
FPC	Fuel performance codes
FR	Fast reactor
FZJ	Forschungszentrum Jülich GmbH
GANEX	Group ActiNide EXtraction
IAEA	International Atomic Energy Agency (Austria)
IEMPT	Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation
INL	Idaho National Laboratory (United States)
JAEA	Japan Atomic Energy Agency
JETRO	Japan External Trade Organisation
JRC	Joint Research Centre (European Commission, Belgium)
J-PARC	Japan Proton Accelerator Research Complex
KAERI	Korea Atomic Energy Research Institute
LBE	Lead-bismuth eutectic
MA	Minor actinide
MIMOSA	MultI-recycling strategies of LWR SNF focusing on MOlten SAIt technology

MOFs	Metal-organic frameworks
MOX	Mixed oxide
MSR	Molten salt reactor
MSTCL	Molten Salt Test Thermal Convection Loop
MSTEC	Molten Salt Thermophysical Examination Capability
MYRRHA	Multi-purpose hYbrid Research Reactor for High-tech Applications (Belgium)
NEA	Nuclear Energy Agency
NIRO	Nuclear Innovation and Research Office (United Kingdom)
NNL	National Nuclear Laboratory (United Kingdom)
NSC	Nuclear Science Committee (NEA)
ORNL	Oak Ridge National Laboratory (United States)
P&T	Partitioning and transmutation
PATRICIA	Partitioning And Transmuter Research Initiative in a Collaborative Innovation Action (EU-Horizon 2020 project)
PIE	Post-irradiation examination
PuMMA	Plutonium Management for More Agility
R&D	Research and development
SAC	Scientific Advisory Committee
SANEX	Selective ActiNide EXtraction
SCK CEN	Belgian Nuclear Research Centre
SELECT	Solvent Extraction from Liquid Waste using Extractants of CHON-Type for Transmutation
SMR	Small modular reactors
TF-FCPT	Task Force on Demonstration of Fuel Cycle Closure including Partitioning and Transmutation (P&T) for Industrial Readiness by 2050
TODGA	TetraoOctyl DiGglycolAamide
TRL	Technology readiness level
TRU	Transuranic
TRUEX	Transuranic Extraction
WPFC	Working Party on Scientific Issues of Advanced Fuel Cycles (NEA NSC)
WISARD	Joint Project on Waste Integration for Small and Advanced Reactor Designs (NEA)

## *Executive summary*

The Nuclear Energy Agency (NEA) Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation (IEMPT) has been organised since 1990 as a forum for experts to present and discuss the latest advancements in partitioning and transmutation (P&T). The 16<sup>th</sup> Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation (16IEMPT) was held at the NEA offices in Boulogne-Billancourt, France, from 24 to 27 October 2023, in collaboration with the International Atomic Energy Agency (IAEA). The meeting was supported by the EU-funded Horizon-2020 Partitioning and Transmuter Research Initiative in a Collaborative Innovation Action (PATRICIA) project, the French Alternative Energies and Atomic Energy Commission (CEA), the Multi-purpose hYbrid Research Reactor for High-tech Applications (MYRRHA) project, and the Japan Atomic Energy Agency (JAEA).

Focus areas included national and international nuclear programmes, fuel cycle strategies and scenarios, advanced nuclear fuel recycling, waste management, and innovative utilisation of actinide and fission products. In addition, the meeting addressed advanced systems and research and development (R&D) infrastructures for fuel cycles and P&T, alongside data and modelling developments. The presentations and poster sessions provided a comprehensive platform for discussing ongoing research, technical and strategic insights, and policy directions for P&T.

Over 90 participants from 16 countries and 3 international organisations attended the meeting. The programme included 7 technical sessions with 51 presentations, 20 posters and 2 special panel sessions commemorating the 30<sup>th</sup> anniversary of IEMPT and discussing future directions for P&T.

The discussions covered a range of key topics including:

- **International collaboration and national programmes:** Representatives from international organisations and various countries showcased advancements in P&T technologies, efforts to close the nuclear fuel cycle, and the relevance of circular economy principles, emphasising the critical role of international collaboration in deploying new technologies.
- **Fuel cycle strategies:** Presentations focused on strategic approaches to nuclear fuel cycles, including several EU-funded projects and examination of the readiness of P&T technologies for industrial deployment by 2050. Discussions also covered material flows to support sustainable nuclear waste management strategies.
- **Fuel recycling innovations:** Participants shared insights on aqueous and pyrochemical separation processes, innovations in actinide recycling, the reprocessing of molten salt reactor (MSR) fuels, and advancements in technologies for recovering minor actinides from nuclear waste.
- **Waste management and material reuse:** Discussions centred on advanced waste management strategies, including techniques for treating volatile fission products and the innovative reuse of actinides in applications such as space power systems. Thermal calculations for geological repositories were also discussed.
- **Advanced fuels for fast reactors:** Researchers presented studies on advanced fuels designed for fast reactors, focusing on the effects of minor actinides on fuel performance and new fabrication techniques for targets with high concentrations

of americium. The integration of advanced fuel performance codes to enhance predictive modelling was also discussed.

- **Advanced systems and R&D infrastructures:** Presenters addressed the development of research and development infrastructures needed to support advanced fuel cycles, including material testing under extreme conditions, recent advancements in MSR technologies, and the role of international research facilities in fostering innovation.
- **Modelling and data:** Presentations focused on the application of advanced modelling techniques in P&T research, addressing nuclear data uncertainties, the thermophysical properties of new materials, and the importance of experimental validation for improving the accuracy of predictive models.

The extended abstracts are available on the NEA 16IEMPT web page ([www.oecd-nea.org/jcms/pl\\_20161](http://www.oecd-nea.org/jcms/pl_20161)).

The meeting emphasised the need for continued international collaboration and innovation in the fuel cycle community, with P&T technologies playing a key role in advancing sustainable fuel cycles. Discussions highlighted the importance of adapting P&T to global energy shifts, improving communication with governments, the public and stakeholders at large, and engaging the next generation of researchers. Future efforts will centre on expanding P&T's scope and fostering cross-disciplinary collaboration towards the industrialisation of advanced technologies for closing the nuclear fuel cycle.

## 1. Introduction

### 1.1. Background

Partitioning and transmutation (P&T) technology has emerged as a vital component in the global efforts to reduce the heat, radiotoxicity and volume of radioactive waste from nuclear energy production. Since 1990, the NEA has organised biennial Information Exchange Meetings on Actinide and Fission Product Partitioning and Transmutation (IEMPT) to provide an essential platform for experts from around the world to exchange knowledge, present advancements and collaborate on P&T science, technology and strategies.

The first IEMPT was held in Mito, Japan, in 1990, marking the beginning of a series of meetings that have played a pivotal role in advancing the science and application of P&T technologies. Since then, these meetings have been held in various international locations, in Belgium, Czechia, France, Japan, Korea, Spain, the United Kingdom and the United States.

Each IEMPT has covered key topics related to the development and implementation of P&T within advanced nuclear fuel cycles, such as fuel cycle strategies, radioactive waste management, transmutation fuels, advanced separation radiochemistry, transmutation systems of various technologies and the role of P&T in the context of future energy strategies. These meetings have also facilitated the emergence of various projects on cross-cutting topics in the fields of material research, coolant technologies and fundamental data for key materials, as well as discussions on rising challenges such as the policy developments necessary to support P&T technologies and their economic implications.

The 16<sup>th</sup> IEMPT, held at the NEA headquarters in Boulogne-Billancourt, France, from 24 to 27 October 2023, continued this tradition of fostering international co-operation and knowledge sharing. Organised in collaboration with the IAEA and supported by key contributors including the EU-funded Horizon-2020 PATRICIA Project, the CEA, the MYRRHA Project, and the JAEA, the conference featured a diverse range of topics, including advanced nuclear fuel recycling, waste management and innovative uses of actinides and fission products. Additionally, the event stressed the need for cross-disciplinary collaboration towards industrialisation of advanced technologies for closing the nuclear fuel cycle.

### 1.2. Objectives and scope

The 16<sup>th</sup> IEMPT focused on advancing the development of P&T technologies to improve nuclear waste management. The meeting served as a forum to discuss recent progress in P&T and its integration into advanced nuclear fuel cycles, aiming to:

- share state-of-the-art research and development on P&T processes and technologies;
- strengthen international collaboration by connecting experts, researchers and stakeholders to address challenges and opportunities in fuel cycle strategies;
- provide insight into the technical developments necessary to support the transition to sustainable, advanced nuclear fuel cycles.

The meeting featured seven technical sessions:

- **Session 1: International organisations and national programmes**
  - Featuring presentations from the NEA, the IAEA, the European Commission and several countries.
- **Session 2: Fuel cycle strategies and scenarios**
  - Exploring various strategic approaches to closing the nuclear fuel cycle and integrating P&T.
- **Session 3: Advanced nuclear fuel recycling**
  - Highlighting the most recent advancements in recycling technologies, such as various aqueous and pyrochemical solvent extraction techniques.
- **Session 4: Waste management and innovative utilisations of actinides and fission products**
  - Addressing innovative waste management strategies and novel uses for separated isotopes, including applications in medical and space power systems.
- **Session 5: Advanced fuels for plutonium management and minor actinide transmutation**
  - Focusing on the development of advanced fuel forms for plutonium multi-recycling and minor actinide transmutation, including the need for experimental validation programmes.
- **Session 6: Advanced systems for R&D infrastructure for advanced fuel cycles and P&T**
  - Covering developments in reactor systems, materials testing and research infrastructures for supporting industrial applications of P&T.
- **Session 7: Modelling and data**
  - Focusing on modelling and simulation advancements, including improvements to nuclear data, fuel properties and fuel performance codes, and uncertainty evaluation and propagation methods.

In addition to the seven technical sessions, two special panel discussions provided insights from leaders in the field:

- **Special Panel Session I: “30<sup>th</sup> Anniversary + 3”**
  - Panellists reflected on how the IEMPT meetings have shaped global P&T efforts over the past 30 years while sharing personal highlights from past meetings.
- **Special Panel Session II: “Towards the Future”**
  - Panellists explored the future of nuclear energy, discussing the role of R&D in closing the nuclear fuel cycle, the sustainability of nuclear energy, and the major challenges facing the industry. They also highlighted strategies to maintain interest in P&T research and transition from lab-scale demonstrations to the industrialisation of advanced fuel cycle technologies by 2050.

The subsequent chapters provide details from all the sessions, with the full meeting programme available in Appendix B. The extended abstracts are available on the NEA 16 IEMPT webpage.

## 2. Opening remarks

### 2.1. Welcome address from the NEA

William D. Magwood, IV, the Director-General of the NEA, opened the 16<sup>th</sup> IEMPT by highlighting the significance of the meeting at a crucial time for nuclear energy. He noted that many countries are turning to nuclear power for energy security to meet climate goals, emphasising the role of P&T technologies in advancing nuclear fuel cycles. He praised the ongoing work in P&T and pointed to the importance of collaboration in driving these technologies from research into industrial applications.

The Director-General discussed the NEA's active involvement in promoting P&T efforts, particularly through the work of the Task Force on Demonstration of Fuel Cycle Closure including Partitioning and Transmutation (P&T) for Industrial Readiness by 2050 (TF-FCPT). He also mentioned the then upcoming NEA Joint Project on Waste Integration for Small and Advanced Reactor Designs (WISARD, see [www.oecd-nea.org/jcms/pl\\_86832](http://www.oecd-nea.org/jcms/pl_86832)), which aims to explore how front-end and design phase decisions impact back-end strategies to support sustainable future nuclear systems. He further acknowledged the challenges posed by climate change and urged attendees to focus on the long-term future of nuclear technologies, which are essential to addressing global energy demands. Concluding his remarks, he expressed optimism for the discussions ahead and stressed the need for fresh thinking and innovation to move P&T technologies forward.

### 2.2. Welcome address from the Chair

Prof. Robin J. Taylor (NNL, United Kingdom), the chair of the exchange meeting, welcomed the participants to the 16<sup>th</sup> IEMPT on behalf of the Scientific Advisory Committee (SAC). He acknowledged the challenges in organising the meeting due to global events since the last IEMPT in 2018, which resulted in delays and a venue change. However, he highlighted the strong value of the meeting as a unique opportunity for researchers and experts in advanced fuel cycles to come together. The format, with one session track, was designed to cover a broad range of topics – from international programme status to scenarios and technologies for recycling and waste management.

Prof. Taylor emphasised the importance of discussions on P&T technologies, particularly in ensuring nuclear energy's role in providing secure, low-carbon energy. He encouraged attendees to take full advantage of the oral and poster sessions and to actively engage in the closing session, which is a distinctive feature of IEMPT meetings, offering a chance to discuss the technical programme and refine future meetings. Finally, he recognised the growing trend of holding meetings online but reinforced the importance of in-person collaboration, thanking everyone for their participation and wishing them a fruitful experience at the meeting in Boulogne-Billancourt.

### 3. Summaries of sessions

#### 3.1. Special panel session I – “30<sup>th</sup> Anniversary + 3”

Christian Ekberg (Chalmers University of Technology, Sweden) moderated the first panel session, featuring Bernard Boullis (CEA, France), Takehiko Mukaiyama (JETRO, Japan), Vincenzo Rondinella (European Commission), and Jan Uhlíř (ÚJV Řež, Czechia).

The panellists initiated the session by providing presentations about their experiences from the past IEMPT meetings and sharing their opinions about the path forward for advanced nuclear fuel cycles.

##### **Evolution and challenges for P&T**

The panel discussed the need for P&T to evolve over the next 30 years by remaining open to new ideas and broadening the scope beyond traditional boundaries. One significant point is the importance of increased collaboration with the geological disposal community to find aligned solutions for managing nuclear waste. The panel also highlighted the benefits of closed fuel cycles: reducing the radiotoxicity, heat and volume of radioactive waste, while improving the sustainability and efficiency of the fuel cycle. Effective communication, especially in terminology, was deemed crucial for ensuring mutual understanding and progress across different sectors and communities.

##### **Major challenges with P&T and potential solutions**

The need for broader involvement from stakeholders – including decision makers, geological disposal experts, and the public – was identified as a critical challenge. The panel emphasised that increased engagement with and the inclusion of these groups would help address concerns and build a more holistic approach to nuclear fuel cycle management.

##### **Implementation of the first fully closed fuel cycle**

The panellists underscored that while countries like Russia and China are making rapid progress in this area, significant strides are also being made in countries such as France and Japan. They expressed optimism that these advancements could lead to the implementation of the first fully closed fuel cycle in the near future.

#### 3.2. Special panel session II – “Towards the Future”

Sungyeol Choi (Seoul National University, Korea) moderated the second panel session, featuring Hamid Aït Abderrahim (MYRRHA, Belgium), Kristine Madden (International Youth Nuclear Congress), Ken Marsden (INL, United States), Dan Mathers (NIRO, United Kingdom), and Bertrand Morel (Orano, France).

The panellists discussed the future of nuclear energy, focusing on the role of R&D in closing the nuclear fuel cycle, the sustainability of nuclear energy, and strategies to overcome key industry challenges. They also highlighted ways to maintain interest in P&T research.

##### **The importance of communication around P&T**

The panel stressed the need for clear and tailored communication about P&T technologies, noting that different stakeholders, such as scientists, policymakers and the public, require distinct messaging. For the public, in particular, accessible language is crucial. US

marketing research has shown that terms like “used fuel” instead of “spent fuel” and “recycling” instead of “reprocessing” tend to lead to more positive reactions.

### **Technical challenges remaining with P&T**

Developing solid fuels containing minor actinides remains a significant technical challenge, especially when considering large-scale demonstration. While there has been extensive experience with mixed oxide (MOX) fuel since the 1990s, multi-recycling of Pu has not been conducted. Incorporating minor actinides in the fuel cycle adds complexity, with demonstration only achieved at lab scale. One solution may lie in exploring alternatives to solid fuels, such as in molten salt reactors (MSR), which can more easily manage the separation and use of minor actinides. However, MSR technologies still face technical challenges, particularly in separating fission products from the fuel. Pre-industrial demonstrations will facilitate progress and help narrow down options.

### **Attracting the younger generation to advanced fuel cycles**

The panel discussed the need to make nuclear energy more appealing to younger generations. Simplifying the communication around nuclear technologies and increasing engagement with young professionals were seen as key strategies. Innovative projects were highlighted for their appeal to the younger generation, particularly regarding the societal value of reducing the burden of high-level waste. Additionally, the panel also noted that skills from the nuclear sector are transferable to areas like medical isotopes and space exploration, broadening the appeal. Startups, which move quickly and offer exciting challenges, were also seen as important in attracting young professionals.

## **3.3. Session 1 – International organisations and national programmes**

Gabriele Grassi (NEA) and Clément Hill (IAEA) chaired the first technical session of the meeting, which featured ten presentations from three international organisations and seven countries. Speakers included Tatiana Ivanova (NEA), Clément Hill (IAEA), Vincenzo Rondinella (EU-JRC), Hamid Aït Abderrahim (MYRRHA, Belgium), François Sudreau (CEA, France), Smitha Manohar (BARC, India), Kenji Nishihara (JAEA, Japan), Jong-Hyuk Baek (KAERI, Korea), Dan Mathers (NIRO, United Kingdom) and Ken Marsden (INL, United States). The presentations highlighted advancements in nuclear fuel cycles, with a focus on P&T technologies designed to reduce the radiotoxicity and volume of nuclear waste.

Global interest in moving beyond open fuel cycles, where spent nuclear fuel is disposed of after cooling, remains strong. Countries are exploring ways to partially or fully close the nuclear fuel cycle, including mono-recycling in water-cooled reactors, multi-recycling in fast-spectrum reactors (including MSRs), and incorporating accelerator-driven systems (ADS). The discussions highlighted progress in separating plutonium, minor actinides and fission products using hydro or pyrochemical processes – strategies that have already been demonstrated at a laboratory scale in several countries.

The concept of the “circular economy” was highlighted as increasingly relevant in nuclear energy. The approach optimises the use of natural resources and reduces the ultimate waste inventory, thereby improving public perception and acceptability of nuclear energy while minimising the environmental footprint of mines (front-end) and geological repositories (back-end).

Presentations also discussed the partitioning options developed over the past decades, including applications other than fabrication of new nuclear fuels and/or transmutation targets. While backed by experimental results and predictive models, these technologies

need to progress towards pre-industrial scale, focusing on engineering and performance demonstration.

Additionally, the importance of international collaboration was underscored. Increasing the technology readiness level (TRL) of new P&T technologies and ensuring their industrial deployment will require concerted efforts at both the bilateral and multilateral levels. The involvement of private investors and startups, alongside traditional state-owned institutions, was noted as a growing trend, bridging new perspectives and innovative approaches to research and development. Therefore, new initiatives can benefit from public-private partnerships.

Finally, engaging the public and policymakers will be crucial to the future deployment of nuclear technologies. Clear and effective communication is necessary to demonstrate the benefits of nuclear energy with a fully closed fuel cycle in achieving net zero by 2050 while ensuring the security of energy supply. Scientists and engineers must adapt their messaging to gain public acceptance and support policy evolution in favour of sustainable and flexible nuclear solutions.

### 3.4. Session 2 – Fuel cycle strategies and scenarios

Francisco Álvarez-Velarde (CIEMAT, Spain), Kenji Nishihara (JAEA, Japan), and Josh Turner (NNL, United Kingdom) chaired the second session of the meeting. This session included seven presentations from Paul Schuurmans (SCK CEN, Belgium), Nathalie Chauvin (CEA, France), Isabelle Morlaes (Orano, France), Hamid Ait Abderrahim (MYRRHA, Belgium), Jin Whan Bae (ORNL, United States), Kenji Nishihara (JAEA, Japan) and Kenji Takeshita (Tokyo Institute of Technology, Japan). The session offered a detailed examination of fuel cycle strategies and various scenarios.

Among the EU-funded Horizon-2020 projects, the PATRICIA Project made notable progress in addressing the chemical partitioning and safety issues in lead and lead-bismuth cooled systems. The Plutonium Management for More Agility (PuMMA) Project focused on the properties of fuel with high plutonium content, a critical factor in various stages of the fuel cycle of fast reactors (FRs). The Multi-recycling strategies of LWR SNF focusing on Molten Salt technology (MIMOSA) Project explored the use of molten salt reactor technologies to close the nuclear fuel cycle, concentrating on chloride salts and the associated nuclear data.

The NEA Task Force on fuel cycle closure including P&T is preparing a comprehensive report that will provide policymakers with insights into the industrial readiness of P&T technologies and the actions needed to bring them from a pre-industrial scale to industrialisation by 2050. The report will address technical, economic and societal aspects, offering a holistic view of these technologies.

Additionally, the session highlighted three nuclear fuel cycle analyses that assessed material flows from both front-end and back-end perspectives. These analyses covered a range of scenarios from open to fully closed cycles, considering factors such as net zero emissions, waste production and nuclear waste repository sizes. These aspects are key for shaping future waste management strategies in collaboration with the disposal community.

### 3.5. Session 3 – Advanced fuel recycling

Pavel Souček (EC-JRC), Tsuyoshi Murakami (CRIEPI, Japan) and Iván Sánchez-García (CIEMAT, Spain) chaired the third session of the meeting dealing with separation techniques for advanced fuel recycling. There were eight presentations from Jan Uhlíř (ÚJV Řež, Czechia), Andreas Wilden (FZJ, Germany), Tatsuro Matsumura (JAEA, Japan),

Tsuyoshi Murakami (CRIEPI, Japan), Iván Sánchez-García (CIEMAT, Spain), Billy Keywood (NNL, United Kingdom), Colin Boxall (Lancaster University, United Kingdom) and Pavel Souček (EU-JRC). Aqueous and pyrochemical separation processes for both conventional and advanced fuels recycling were discussed, as well as homogeneous and heterogeneous actinide recycling strategies. An overall scenario for molten salt reactor (MSR) fuel recycling was introduced. Finally, the contributions included advanced fuel preparation, involving both solid and liquid fuels. More details from the presentations are given below.

### **Aqueous separation processes**

- The process called Solvent Extraction from Liquid Waste using Extractants of Carbon (C), Hydrogen (H), Oxygen (O), and Nitrogen (N) (CHON)-Type for Transmutation (SELECT) for the heterogeneous separation of actinides from high-level liquid waste was successfully demonstrated with genuine high active raffinate and 0.3 g of minor actinides recovered (Japan).
- Innovative Selective ActiNide Extraction (SANEX), effectively established in 2013, was further developed using CHON-based extractant (PyTri-Diol) with recovery of Am+Cm > 99.9% (Germany, GENIORS Project).
- Neptunium behaviour during the Group ActiNide EXtraction (GANEX) process for the homogeneous recycling of actinides was studied and the stabilisation of Np(IV) was greatly improved using Ce(IV) stabilisation (United Kingdom).
- Irradiation studies of Tetraoctyl Diglycolamine (TODGA) extractant used for both homogeneous and heterogeneous recycling processes (Euro GANEX, i-SANEX, Americium Selective Separation [AmSel]) with different complexation were carried out and successfully evaluated (Spain).

### **Pyrochemical separation processes**

- Fluoride volatility methods for recycling fast reactor MOX fuel and electrochemical separation processes for the clean-up of MSR fuel were developed (Czechia).
- A flowsheet based on different pyrochemical processes (liquid metal – molten salt reductive extraction, electrowinning, glassification, phosphate precipitation) was developed for recycling MSR chlorides (Japan).

### **Advanced fuel preparation**

- The photochemical reduction of U(VI) and Pu(IV) prior to oxalate precipitation for the advanced MOX fuel preparation was developed and successfully demonstrated, including with Pu active tests (United Kingdom).
- A synthesis technique for phase pure and thermally stable PuCl<sub>3</sub> for MSR fuel was developed and established in gram scale (EU-funded MIMOSA Project).

### **Takeaways from the session and discussions**

The main takeaways from the session and follow-up discussion can be summarised in the following points:

- Aqueous separation processes are constantly improving, and some have reached very high maturity levels (e.g. SELECT, i-SANEX, AmSel).
- The feasibility of these processes to achieve the minor actinide recovery has been demonstrated, in some cases including hot tests with genuine irradiated spent fuel.

- There is a positive trend to replace the original extractants with CHON-based molecules.
- The insights into the chemical basics of radio- and photochemical reactions and the distribution behaviour of the separated elements are deepening.
- Easier nicknames for some of the extractants would help in communication.
- There is steady progress in basic studies about MSR fuel salt preparation and reprocessing of its spent fuel salt for both fluoride and chloride systems.
- Knowledge and know-how on molten salt accumulated through long-term developments in pyrochemical reprocessing plays an important role in popularising the MSR technology in the short term.
- The high potential of MSRs in P&T systems is attracting worldwide interest, which encourages experts to tackle remaining issues in the implementation of the pyrochemical recycling process and makes young scientists aware of the attractiveness of pyrochemistry.
- On the other hand, the development of pyrochemical processes for solid advanced fuels seems to be gaining less attention.

Taking advantage of the strong and long-standing collaboration between research groups worldwide focused on advanced fuel recycling, follow-up discussions encouraged future work. Beyond the basic principles of the discussed processes, methods and flow sheets, the contributors tackled engineering and scaling-up issues. This shift highlights the increasing maturity of core processes, paving the way for the implementation of the advanced fuel recycling processes soon – a significant change from the sentiment of previous meetings.

### 3.6. Session 4 – Waste management and innovative utilisations of actinides and fission products

Sungyeol Choi (Seoul National University, Korea) and Rebecca Sanderson (NNL, United Kingdom) chaired the fourth session of the meeting. There were five presentations in this session by Robin Taylor (NNL, United Kingdom), Josh Turner (NNL, United Kingdom), Masahiko Nakase (Tokyo Institute of Technology, Japan), Rebecca Sanderson (NNL, United Kingdom), and Rahul Tripathi (BARC, India). The presentations focused on recent progress in waste management stemming from advanced nuclear fuel cycle options and emphasised the evolving role of partitioning and transmutation (P&T). Notably, P&T is extending its scope beyond traditional realms, now embracing the reuse and recycling of components from spent nuclear fuels. This expansion of focus aligns with current international reviews conducted by the Expert Group on Fuel Recycling and Waste Technology (EGFRW) at the NEA. The group's recent initiatives encompass volatile fission product treatment, curium management and an international review targeting the reuse and recycling of specific components such as non-actinides and structural materials from spent nuclear fuels. They are also conducting an inter-comparison of simulation codes for solvent extraction and developing an international database of extractant ligands. Complementing these efforts, the group has started looking into the chemistry of fuel cycles for MSR technologies.

A notable ambition of this collective effort is the drive towards near-zero emissions of volatile fission products, as outlined in the NEA's recent report, "Treatment of Volatile Fission Products". This initiative aims to enhance reprocessing technologies to significantly reduce emissions of key isotopes like I-129, H-3, C-14 and Kr-85, thereby aligning with societal and environmental standards. Innovative approaches such as the off-

gas capture of I-129 and Kr-85 using nanomaterials (e.g. covalent organic frameworks [COFs], metal-organic frameworks [MOFs]) were presented, along with discussions on new waste forms and strategies like encapsulation versus incorporation.

The session also shed light on the diverse new applications of recovered actinides and fission products, such as in space power systems and gamma-ray source production, thereby broadening its appeal to various communities. The United Kingdom's progress in producing pure AmO<sub>2</sub> was a highlight, detailing the separation method of Am from Pu, the achievement of over 99% purity in AmO<sub>2</sub> production, and the prospective scale-up at the PuMA-2 facility for annual production of 500 g of Am-241. Similarly, India's advancements in recovering Cs-137 as Cs glass pencils at a plant-scale using the Combined Air Lifting and Mixing (CALMIX) system were noted, with approximately 240 Cs-137 pencils recovered so far. However, challenges such as quality checks and remote maintenance were acknowledged.

The session concluded with insights into the thermal calculation for geological repositories, emphasising the importance of accounting for the heterogeneous nature of vitrified glass waste, particularly in terms of waste loading and cooling time. An efficient calculation scheme combining ANSYS results with machine learning was proposed for the thermal design of geological repositories for high-level waste, making a significant step towards more accurate and sustainable waste management strategies.

### 3.7. Session 5 – Advanced fuels for plutonium management and minor actinide transmutation

Nathalie Chauvin (CEA, France), Luca Capriotti (INL, United States) and Martina Di Gennaro (Polimi, Italy) chaired the fifth session of the meeting. There were eight presentations in this session from Daniel Shepherd (NNL, United Kingdom), Gamze Çolak (SCK CEN, Belgium), Luca Capriotti (INL, United States), Catherine Sabathier (CEA, France), Marc Lainet (CEA, France), Martina Di Gennaro (Polimi, Italy), Tommaso Barani (CEA, France) and Florian Marconi (CEA, France). This session provided an overview of current knowledge and recent advancements in the field of innovative fuels used in Generation IV reactors with the aim of reducing the amount of high-level waste and maximising the energy efficiency of nuclear fuel. A key area of interest was understanding how the presence of minor actinides and a high content of plutonium in the fuel influences the parameters in the fuel cycle and assessing their behaviour under fast reactor irradiation conditions. Both homogeneous and non-homogeneous (minor actinide bearing blanket) transmutation strategies were explored.

To assess the impact on fuel performance, several irradiation experiments were conducted in the past under fast reactor neutron spectra. Post-irradiation examination (PIE) of metal fuel alloys, specifically (U,Pu,Am,Np)Zr, revealed that the addition of minor actinides (as found in AFC-1, FUTURIX-FTA and X501 samples) had no discernible effect on fuel performance. The behaviour of metallic fuel pins was found to be similar in both irradiation campaigns (AFC-1 and FUTURIX-FTA), comparable to experimental breeder reactor (EBR)-II experiments. Furthermore, advanced characterisations of oxide-based fuel disks with 20 wt.% americium incorporation demonstrated that those with a porous microstructure remained mostly intact, while all disks with a dense microstructure were found to be fragmented.

For the fabrication of transmutation targets with high concentrations of americium (greater than 10%), improvements have been made in the handling of actinide powder operations. Recent advancements involve the adoption of a hybrid method combining internal gelation

and infiltration, providing various benefits such as preventing powder accumulation, reducing operator exposure and eliminating the generation of liquid waste.

The design of irradiation experiments and the licensing of test facilities require the use of the state-of-the-art fuel performance codes (FPCs) capable of accounting for the impact of plutonium and minor actinides. In this regard, studies conducted over the past 60 years on the oxygen potential (of particular importance for predicting the chemical interaction between fuel and cladding) in high plutonium content MOX fuels (20-25% PuO<sub>2</sub>) were summarised during this session, recommending the use of the Kato's model in FPCs. This literature review also highlighted that the presence of neptunium has no significant effect on the oxygen potential, while the presence of americium, up to 5% results in a significant increase. The accuracy and predictive capabilities of FPCs can be enhanced by coupling them with high-fidelity neutronic and thermal-hydraulic codes for simulating both normal and accidental conditions. Two studies focused on the results obtained with the FPC TRANSURANUS, properly informed by more specific and reliable thermal-hydraulic and neutronic boundary conditions obtained using the fluid dynamics code OpenFOAM and the Monte Carlo neutronic code SERPENT. Lastly, recent developments in the GERMINAL code were evaluated against irradiation experiments with homogeneous americium targets irradiated in the JOYO and PHÉNIX sodium fast reactors, showing good agreement with experimental quantities.

### 3.8. Session 6 – Advanced systems and R&D infrastructures for advanced fuel cycles and P&T

Andrea Salvatores (CEA, France), Takanori Sugawara (JAEA, Japan), and Gamze Çolak (SCK CEN, Belgium) chaired the sixth session of the meeting. There was a total of eight presentations in this session from Alessandro Marino (SCK CEN, Belgium), Stefan Holmström (SCK CEN, Belgium), Fujio Maekawa (JAEA, Japan), Hironari Obayashi (JAEA, Japan), Takanori Sugawara (JAEA, Japan), Toni Karlsson (INL, United States), Byung Gi Park (Soonchunhyang University, Korea) and Sungyeol Choi (Seoul National University, Korea). The session explored how the management of infrastructures for advanced fuel cycles and P&T is approached through a comprehensive strategy, addressing various concrete aspects ranging from the complex chemistry of lead-bismuth eutectic (LBE) systems to material evaluation under diverse corrosion and ageing conditions. The endeavour involves the development of cutting-edge equipment, such as ultrasonic flowmeters and electromagnetic velocimeters, to enhance precision and efficiency in monitoring and analysis. Component design is a crucial facet, encompassing elements like the beam window in the spallation target region, necessitating meticulous engineering to ensure optimal performance.

In the pursuit of robust infrastructures, failure analysis plays an essential role, allowing for a thorough understanding of potential weaknesses and vulnerabilities. The application of advanced modelling techniques, including large-scale thermal-hydraulic analysis and the study of bubble growth, contributes to the predictive and preventive aspects of infrastructure management.

The advancement of fuel cycles and the implementation of P&T techniques foster the creation of innovative facilities. Noteworthy examples include a new facility at the Japan Proton Accelerator Research Complex (J-PARC), managed by the JAEA. Additionally, the Molten Salt Thermophysical Examination Capability (MSTEC), established by the Idaho National Laboratory (INL), and the Molten Salt Thermal Convection Loop (MSTCL), managed by Soonchunhyang University, showcase the commitment to cutting-edge research and development in the field.

These facilities serve as instrumental platforms for exploring and refining technologies related to molten salts and the characterisation of transuranic elements. The collective efforts and collaborations across these entities underscore the global commitment to advancing scientific understanding and technological capabilities in the realm of advanced nuclear infrastructure and fuel cycle management.

### 3.9. Session 7 – Modelling and data

Luca Fiorito (SCK CEN, Belgium) and Maxime Fache (Technical University of Denmark & JRC) chaired the final session of the meeting. There were six presentations in this session from Francisco Álvarez-Velarde (CIEMAT, Spain), Daniel Wojtaszek (CNL, Canada), Maxime Fache (Technical University of Denmark & JRC), Hongyan Chen (University of Manchester, United Kingdom) and Hiroki Iwamoto (JAEA, Japan). The session focused on the use of advanced modelling techniques to support P&T research and nuclear fuel cycle developments. Key topics included the prediction of minor actinides in irradiated fuel, fuel design for advanced reactors, proliferation resistance, thermophysical properties of innovative materials, and spallation models and the chemistry of nuclear separation.

The session highlighted the multidisciplinary nature of P&T modelling, with expertise required across various domains. Presenters emphasised the extensive capabilities available for modelling specific aspects of P&T, while stressing the importance of systematically addressing uncertainties within these models. The discussions also covered the verification and validation of models through benchmarking against experimental results.

A major conclusion from this session was the crucial role of experiments in developing and refining models. The combination of experimental data with advanced simulation tools helps enhance the accuracy of predictions and drive innovation in nuclear fuel design and waste management processes.

### 3.10. Poster session

The poster session, chaired by Paul Schuurmans (SCK CEN, Belgium), featured 20 posters covering a variety of topics, including advancements in reactor design and fuel reprocessing. Appendix C provides the full list of contributors and their respective poster topics.

#### **Advances in nuclear fuel reprocessing**

Several posters presented innovative approaches to nuclear fuel reprocessing. Hybrid extraction techniques, using solvent extraction and extraction chromatography, were highlighted for their cost-effectiveness. The AmSel (v) flowsheet, using TODGA and SO<sub>3</sub>-Ph-BTBP, was particularly noted as a promising tool for improving the efficiency of reprocessing.

#### **Monitoring and automation**

Some posters also explored developments in monitoring and automation technologies for nuclear processes. Acoustic monitoring systems were discussed as effective tools for proliferation detection and equipment health monitoring in pyroprocessing facilities. Advances in automated systems for partitioning and fuel handling were highlighted, with a specific focus on the analytical chemical separation of active fuel components.

#### **Computational tools**

Several computational tools designed to support extraction simulations and fuel cycle scenarios were presented. The NEA's online fuel cycle scenario code catalogue was

recognised as a valuable resource, offering an extensive list of simulation tools for fuel cycle scenarios. Additionally, a presentation on digital twin models for minor actinide (MA) recycling discussed how chemical modelling and machine learning can seed a digital twin to simulate the TRUEX (TRU Extraction) process in real time, running parallel to the physical process. This approach would enable the rapid identification and diagnosis of potential issues with solvent extraction cascades.

### **Challenges in fuel cycle management**

Key challenges in used fuel management were another focal point. Fast reactors were noted as key to reducing the build-up of used fuel, including MOX fuel, in geological repositories. A comprehensive approach to assessing P&T technologies was emphasised, focusing on both technical aspects and effective communication strategies to advance these technologies. Additionally, research was done to discuss the use of P&T in managing used fuel and producing heavy actinides such as Pu-238, californium and berkelium.

## 4. Conclusions and perspectives

The 16<sup>th</sup> Information Exchange Meeting on Actinide and Fission Product Partitioning (IEMPT) brought together over 90 participants from 16 countries and 3 international organisations. The event featured seven oral sessions with 51 presentations and 20 poster presentations, highlighting a diverse array of research and technological advancements. Additionally, the meeting had 2 special panel discussions, celebrating 30 years of IEMPT conferences and looking towards the future. The wide participation demonstrated the strong global interest in advancing P&T technologies and their role in advanced nuclear fuel cycles.

The meeting underscored the importance of continued collaboration and innovation within the fuel cycle community. P&T technologies were recognised as essential to addressing nuclear waste challenges and advancing sustainable nuclear energy. Additionally, there was a consensus that P&T must evolve to meet the needs of a changing global energy landscape. While P&T remains a central focus, it is increasingly integrated into broader advanced fuel cycle strategies that address technical, economic and societal needs. Cross-disciplinary collaboration is crucial to the transition from lab-scale demonstrations to the industrialisation of advanced technologies for closing the nuclear fuel cycle.

The panel discussions highlighted the importance of effective communication with various stakeholders, including governments, the public and experts in deep geological repository. Concepts like “inter-generational justice” were emphasised, underscoring the responsibility to future generations in managing nuclear waste sustainably. The panellists also stressed the need to engage younger researchers to ensure continuous advancements in P&T technologies. Innovative projects related to Generation IV technologies, accelerator-driven systems (ADS), small modular reactors (SMRs), molten salt reactors (MSRs), etc. can offer opportunities to draw in young scientists.

In terms of future planning, the NEA announced that IEMPT will transition to a three-year cycle, with the 17<sup>th</sup> IEMPT planned to take place in 2026. Additionally, there will be efforts for deeper integration of the disposal community into the discussions.

The 16<sup>th</sup> IEMPT reaffirmed the importance of P&T technologies in the context of advanced nuclear fuel cycles while acknowledging the need for adaptability in the face of global energy challenges. Future meetings will focus on expanding the P&T’s scope, improving stakeholder communication, and continuing to foster cross-disciplinary collaborations to bring these technologies to deployment.



## *Appendix B. Programme*

### **16<sup>th</sup> Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation (16IEMPT)**

Nuclear Energy Agency  
46 Quai Le Gallo,  
92100 Boulogne-Billancourt  
France

Auditorium

24-27 October 2023

The 16<sup>th</sup> IEMPT was organised in collaboration with the International Atomic Energy Agency (IAEA) and supported by the EU-funded PATRICIA Project, MYRRHA Project, the Japan Atomic Energy Agency (JAEA) and the French Alternative Energies and Atomic Energy Commission (CEA).

Day 1 – Tuesday, 24 October 2023					
ID	Item	Speaker	Start	End	
	<b>Registration</b>		08:15	9:15	
	<b>Introduction</b>		09:15	09:35	00:20
	Welcome address from the NEA	DG William D. Magwood, IV			
	Welcome address from the Chair	Robin Taylor (NNL)			
<b>SPS</b>	<b>Special Panel Sessions</b>		09:35	12:00	02:25
SPS-I	<b>Panel Session I – “30th Anniversary + 3”</b> <ul style="list-style-type: none"> <li>• Bernard Boullis (France)</li> <li>• Takehiko Mukaiyama (Japan)</li> <li>• Vincenzo Rondinella (European Commission)</li> <li>• Jan Uhlir (Czechia)</li> </ul>	<u>Moderator:</u> Christian Ekberg (Chalmers University of Technology)	09:35	10:35	01:00
	<i>Coffee break</i>		10:35	11:00	00:25
SPS-II	<b>Panel Session II – “Towards the Future”</b> <ul style="list-style-type: none"> <li>• Hamid Ait Abderrahim (Belgium)</li> <li>• Kristine Madden (International Youth Nuclear Congress)</li> <li>• Ken Marsden (United States)</li> <li>• Dan Mathers (United Kingdom)</li> <li>• Bertrand Morel (France)</li> </ul>	<u>Moderator:</u> Sungyeol Choi (Seoul National University)	11:00	12:00	01:00
	<b>Lunch break</b>		12:00	13:30	01:30
<b>S01</b>	<b>Session 1 – Plenary Session: International organisations and national programmes</b> <u>Chairs:</u> Gabriele Grassi (NEA), Clément Hill (IAEA) <i>(15' presentation + 5' Q&amp;A)</i>		13:30	17:35	04:05
S01.01	Nuclear Energy Agency (NEA)	Tatiana Ivanova (NEA)	13:30	13:50	00:20
S01.02	International Atomic Energy Agency (IAEA)	Clément Hill (IAEA)	13:50	14:10	00:20
S01.03	European Commission (EC)	Vincenzo Rondinella (JRC)	14:10	14:30	00:20
S01.04	Belgium	Hamid Ait Abderrahim (MYRRHA)	14:30	14:50	00:20
S01.05	China	Guoan Ye (CIAE)	14:50	15:10	00:20
	<b>Group photo</b>		15:10	15:20	00:10
	<i>Coffee break</i>		15:20	15:50	00:30
S01.06	France	François Sudreau (CEA)	15:50	16:10	00:20
S01.07	India	Smitha Manohar (BARC)	16:10	16:30	00:20
S01.08	Japan	Kenji Nishihara (JAEA)	16:30	16:50	00:20
S01.09	Korea	Jong-Hyuk Baek (KAERI)	16:50	17:10	00:20
S01.10	United Kingdom	Dan Mathers (NIRO)	17:10	17:30	00:20
S01.11	United States	Ken Marsden (INL)	17:30	17:50	00:20
	<b>Introduction to Poster</b> <u>Chair:</u> Paul Schuurmans (SCK CEN)		17:50	18:00	00:10
<b>Close Day 1 – 18:00</b>					

Day 2 – Wednesday, 25 October 2023					
ID	Item	Speaker	Start	End	
<b>S02</b>	<b>Session 2 – Fuel cycle strategies and scenarios</b> Chairs: Francisco Álvarez-Velarde (CIEMAT), Kenji Nishihara (JAEA), Josh Turner (NNL) (15' presentation + 5' Q&A)		<b>09:00</b>	<b>11:45</b>	<b>02:45</b>
S02.01	PATRICIA: Partitioning and Transmutation Research Initiative in a Collaborative Innovation Action	Paul Schuurmans (SCK CEN)	09:00	09:20	00:20
S02.02	PUMMA, a European project devoted to Plutonium management in the whole fuel cycle	Nathalie Chauvin (CEA)	09:20	09:40	00:20
S02.03	MIMOSA: an EU funded project aiming at demonstrating multi-recycling strategies based on the use of molten salt reactors in European countries	Isabelle Morlaes (Orano)	09:40	10:00	00:20
S02.04	NEA Task Force on Demonstration of Fuel Cycle Closure including Partitioning and Transmutation (P&T) for Industrial Readiness by 2050	Hamid Ait Abderrahim (MYRRHA)	10:00	10:20	00:20
	<i>Coffee break</i>		10:20	10:45	00:25
S02.05	Fuel Cycle Requirements for Deployment of Demonstration Reactors for Achieving Net-Zero Emissions Economy in the United States	Jin Whan BAE (ORNL)	10:45	11:05	00:20
S02.06	Management of MOX spent fuel from LWR: Assessment of material flow	Kenji Nishihara (JAEA)	11:05	11:25	00:20
S02.07	Scenario Study on Sustainable Nuclear Energy Utilisation using Dynamic Nuclear Fuel Cycle Simulator NMB4.0	Kenji Takeshita (Tokyo Institute of Technology)	11:25	11:45	00:20
	<i>Lunch break</i>		11:45	13:15	01:30
<b>S03</b>	<b>Session 3 – Advanced fuel recycling</b> Chairs: Pavel Souček (JRC), Tsuyoshi Murakami (CRIEPI), Iván Sánchez-García (CIEMAT) (15' presentation + 5' Q&A)		<b>13:15</b>	<b>15:55</b>	<b>02:40</b>
S03.01	Current status of R&D on MA separation process using solvent extraction technique for P&T technology	Tatsuro Matsumura (JAEA)	13:15	13:35	00:20
S03.02	Selective actinide(III) separation using 2,6-bis[1-(propan-1-ol)-1,2,3-triazol-4-yl]pyridine (PyTri-Diol) in the innovative-SANEX process: laboratory scale counter current centrifugal contactor demonstration	Andreas Wilden (FZJ)	13:35	13:55	00:20
S03.03	Neptunium behavior in advanced flowsheets	Billy Keywood (NNL)	13:55	14:15	00:20
S03.04	Rapid Photochemical Reduction of U(VI) for the Development of New Mixed Metal Oxide Fuel Production Processes	Colin Boxall (Lancaster University)	14:15	14:35	00:20
S03.05	Effects of metal complexation on radiolytic stability of important minor actinide extractants for advanced nuclear fuel cycles	Iván Sánchez-García (CIEMAT)	14:35	14:55	00:20
S03.06	Fluoride Partitioning Technologies Development in the Czech Republic	Jan Uhlíř (ÚJV Řež)	14:55	15:15	00:20
S03.07	Synthesis of actinide chlorides for Molten Salt Reactor fuels	Pavel Souček (JRC)	15:15	15:35	00:20
S03.08	Pyrochemical Reprocessing of Spent Fuel Salt of Molten Salt Fast Reactor	Tsuyoshi Murakami (CRIEPI)	15:35	15:55	00:20
	<i>Coffee break</i>		15:55	16:20	00:25
<b>S04</b>	<b>Session 4 – Waste management and innovative utilisations of actinides and fission products</b> Chairs: Sungyeol Choi (Seoul National University), Rebecca Sanderson (NNL) (15' presentation + 5' Q&A)		<b>16:20</b>	<b>18:00</b>	<b>01:40</b>
S04.01	The Role of the NEA Expert Group in Fuel Recycling and Waste Technology Supporting the Development of Advanced Fuel Cycle Options	Robin Taylor (NNL)	16:20	16:40	00:20
S04.02	NEA "Treatment of Volatile Fission Products" Report	Josh Turner (NNL)	16:40	17:00	00:20
S04.03	Optimization study of high-level waste repository thermal design by response surface methodology on ANSYS Workbench software	Masahiko Nakase (Tokyo Institute of Technology)	17:00	17:20	00:20
S04.04	Separation of Americium-241 for Space Power Systems	Rebecca Sanderson (NNL)	17:20	17:40	00:20
S04.05	Recovery of Cesium-137 from fission products for Societal Applications	Rahul Tripathi (BARC)	17:40	18:00	00:20
<b>Close Day 2 – 18:00</b>					

Day 3 – Thursday, 26 October 2023					
ID	Item	Speaker	Start	End	
<b>S05</b>	<b>Session 5 – Advanced fuels for plutonium management and minor actinide transmutation</b> <i>Chairs: Nathalie Chauvin (CEA), Luca Capriotti (INL), Martina Di Gennaro (Polimi)</i> <i>(15' presentation + 5' Q&amp;A)</i>		<b>09:00</b>	<b>12:05</b>	<b>03:05</b>
S05.01	Effect of O/M, temperature, Pu and MA content, and irradiation on the oxygen potential of MOX fuels	Daniel Shepherd (NNL)	09:00	09:20	00:20
S05.02	Fabrication of Am-containing transmutation targets	Gamze Çolak (SCK CEN)	09:20	09:40	00:20
S05.03	Overview of US Postirradiation Examination of Transmutation Metallic Fuel Alloys	Luca Capriotti (INL)	09:40	10:00	00:20
S05.04	DIAMINO irradiation on (U0.85Am0.15)O <sub>2</sub> transmutation targets: post irradiation examinations	Catherine Sabathier (CEA)	10:00	10:20	00:20
	<i>Coffee break</i>		<i>10:20</i>	<i>10:45</i>	<i>00:25</i>
S05.05	Advanced interpretation of the SPHERE irradiation experiment with neutronics and fuel performance codes	Marc Lainet (CEA)	10:45	11:05	00:20
S05.06	OpenFOAM-informed TRANSURANUS simulation of the fuel pin behaviour in the MYRRHA reactor during Beam Power Jump transient scenario	Martina Di Gennaro (Polimi)	11:05	11:25	00:20
S05.07	Preliminary assessment of GERMINAL V3 against homogeneous transmutation irradiations	Tommaso Barani (CEA)	11:25	11:45	00:20
S05.08	Study of the AM-1 homogeneous transmutation experiment using the GERMINAL V2 fuel performance code	Florian Marconi (CEA)	11:45	12:05	00:20
	<b>Lunch break</b>		<b>12:05</b>	<b>13:35</b>	<b>01:30</b>
<b>S06</b>	<b>Session 6 – Advanced systems and R&amp;D infrastructures for advanced fuel cycles and P&amp;T</b> <i>Chairs: Andrea Salvatores (CEA), Takanori Sugawara (JAEA), Gamze Çolak (SCK CEN)</i> <i>(15' presentation + 5' Q&amp;A)</i>		<b>13:35</b>	<b>16:15</b>	<b>02:40</b>
S06.01	LBE coolant chemistry research for MYRRHA	Alessandro Marino (SCK CEN)	13:35	13:55	00:20
S06.02	Material property determination of LBE exposed 15-15Ti steel in support of MYRRHA design	Stefan Holmström (SCK CEN)	13:55	14:15	00:20
S06.03	Overview of R&D Activities of J-PARC Center for the ADS Development	Fujio Maekawa (JAEA)	14:15	14:35	00:20
S06.04	Status of LBE/Gas Interaction Based Oxygen Concentration Control in JAEA	Hironari Obayashi (JAEA)	14:35	14:55	00:20
S06.05	PSi - Proton accelerator-driven subcritical virtual system project in JAEA	Takanori Sugawara (JAEA)	14:55	15:15	00:20
S06.06	Molten Salt Thermophysical Examination Capability for Characterisation of TRU and Irradiated Salts	Toni Karlsson (INL)	15:15	15:35	00:20
S06.07	Corrosion failure analysis in molten salt thermal convection loop using NaCl-MgCl <sub>2</sub> salt mixture	Byung Gi Park (Soonchunhyang University)	15:35	15:55	00:20
S06.08	Development of Machine Learning Model for Estimating Electrode Surface Area via Cyclic Voltammetry	Sungyeol Choi (Seoul National University)	15:55	16:15	00:20
	<i>Coffee break</i>		<i>16:15</i>	<i>16:30</i>	<i>00:15</i>
<b>PS</b>	<b>Poster Session</b> <i>Chair: Paul Schuurmans (SCK CEN)</i>		<b>16:30</b>	<b>18:30</b>	<b>02:00</b>
<b>Close Day 3 – 18:30</b>					

## Day 4 – Friday, 27 October 2023

ID	Item	Speaker	Start	End	
<b>S07</b>	<b>Session 7 - Modelling and data</b> Chairs: Luca Fiorito (SCK CEN), Maxime Fache (DTU & JRC) (15' presentation + 5' Q&A)		<b>09:00</b>	<b>11:30</b>	<b>02:30</b>
S07.01	Monte Carlo nuclear data uncertainty propagation in inventory calculations	Francisco Álvarez-Velarde (CIEMAT)	09:00	09:20	00:20
S07.02	Evaluating Spent Fuel Characteristics Based on Lattice Physics Calculations of Hydrogen Moderated High Temperature Gas-cooled Reactors with Uranium and Plutonium Annular Fuel	Daniel Wojtaszek (CNL)	09:20	09:40	00:20
S07.03	NEA Task Force on Dose Rate Calculations for Irradiated Assembly	Francisco Álvarez-Velarde (CIEMAT)	09:40	10:00	00:20
	<i>Coffee break</i>		10:00	10:30	00:30
S07.04	Thermophysical properties of the molten salt fuel NaF-KF-UF <sub>4</sub> : an experimental and modelling study	Maxime Fache (Technical University of Denmark & JRC)	10:30	10:50	00:20
S07.05	Modelling of the distribution of Technetium between nitric acid solutions and TBP-in diluent in the presence of uranium	Hongyan Chen (University of Manchester)	10:50	11:10	00:20
S07.06	Experimental Program on Nuclear Data for Accelerator-Driven Systems Using FFAG Accelerator	Hiroki Iwamoto (JAEA)	11:10	11:30	00:20
	<b>Lunch break</b>		<b>11:30</b>	<b>13:00</b>	<b>01:30</b>
<b>S08</b>	<b>Summary Session</b> Chair: Robin Taylor (NNL)		<b>13:00</b>	<b>15:30</b>	<b>02:30</b>
	Chairpersons' reviews	Session Chairs	13:00	13:35	00:35
	Poster review	Poster Chair	13:35	13:55	00:20
	Discussion	All	13:55	15:10	01:15
	Closing remarks	Chair	15:10	15:30	00:20
<b>Close Meeting – 15:30</b>					

*Appendix C. List of posters*

ID	Title	First author
P01	A nuclear fuel cycle analysis for a small and sustainable electricity mix	Iván Merino (Universidad Católica del Maule)
P02	Management of MOX Spent Fuel from LWR: (1) Thermal design of direct disposal	Takumi Abe (JAEA)
P03	Multifaceted Assessment of P&T Technologies to Current LWR Fuel Cycle	Masahiko Nakase (Tokyo Institute of Technology)
P04	Optimization of Reprocessing Capacity Deployment under Parametric Uncertainty	Jin Whan Bae (ORNL)
P05	NEA-coordinated online catalogue of tools for nuclear fuel cycle simulation	Francisco Álvarez-Velarde (CIEMAT)
P06	Decay heat prediction for the irradiated MOX fuel of MYRRHA	Federico Di Croce (SCK CEN)
P07	Implementation status of MYRRHA phase 1 (MINERVA) and its accelerator reliability demonstration approach	Ulrich Dorda (SCK CEN)
P08	Molten Salts and Pyrochemical Processing Capabilities at the UK's National Nuclear Laboratory	Moya A. Hay (NNL)
P09	Acoustic Monitoring of Pyroprocessing Equipment	Luis A. Ocampo Giraldo (INL)
P10	Drafting Zero-Power Reactor Core Configurations for a Multi-Purpose Molten Salt Reactor Experiment	Bruno Merk (University of Liverpool)
P11	Flowsheet design for the AmSel process using TODGA and SO <sub>3</sub> -Ph-BTBP	Vincent Vanel (CEA)
P12	Process simulation study on a hybrid process combining solvent extraction and low pressure loss extraction chromatography for a reasonable MA(III) recovery process	Yuichi Sano (JAEA)
P13	Chromatographic Reprocessing Process with Nuclide Separations in Hydrochloric Acid Solution System	Tatsuya Suzuki (Nagoaka University of Technology)
P14	Adsorption/Elution Performance of TEHDGA/SiO <sub>2</sub> -P for Am/Cm Recovery from Genuine HLLW	Daisuke Sato (JAEA)
P15	Redox Reactions of Fe(III) and Hydroxamic Acids in Nitric Acid Solutions in the Context of an Advanced PUREX Process	Suzanne Jones (Lancaster University)
P16	Studies into the effect of insoluble fission products on the generation of Ag(II) for the dissolution of MOx fuel	Nick Bramah (Lancaster University)
P17	The Role of Mass Transfer and Chemical Kinetics in Advanced Nuclear Fuel Partitioning and Reprocessing	Stephen Ogezo (Lancaster University)
P18	Development of a TRUEX Digital Twin for Minor Actinide Recycling using Spectral Data Acquisition	Justin T. Cooper (INL)
P19	Advanced Analytical Chemical Separation Techniques for Highly Radioactive Nuclear Fuel Analyses	Jacob Brookhart (INL)
P20	US Heavy Actinide Production at Oak Ridge National Laboratory— Ongoing Actinide Partitioning and Transmutation Programs	Emory D. Collins (ORNL)