

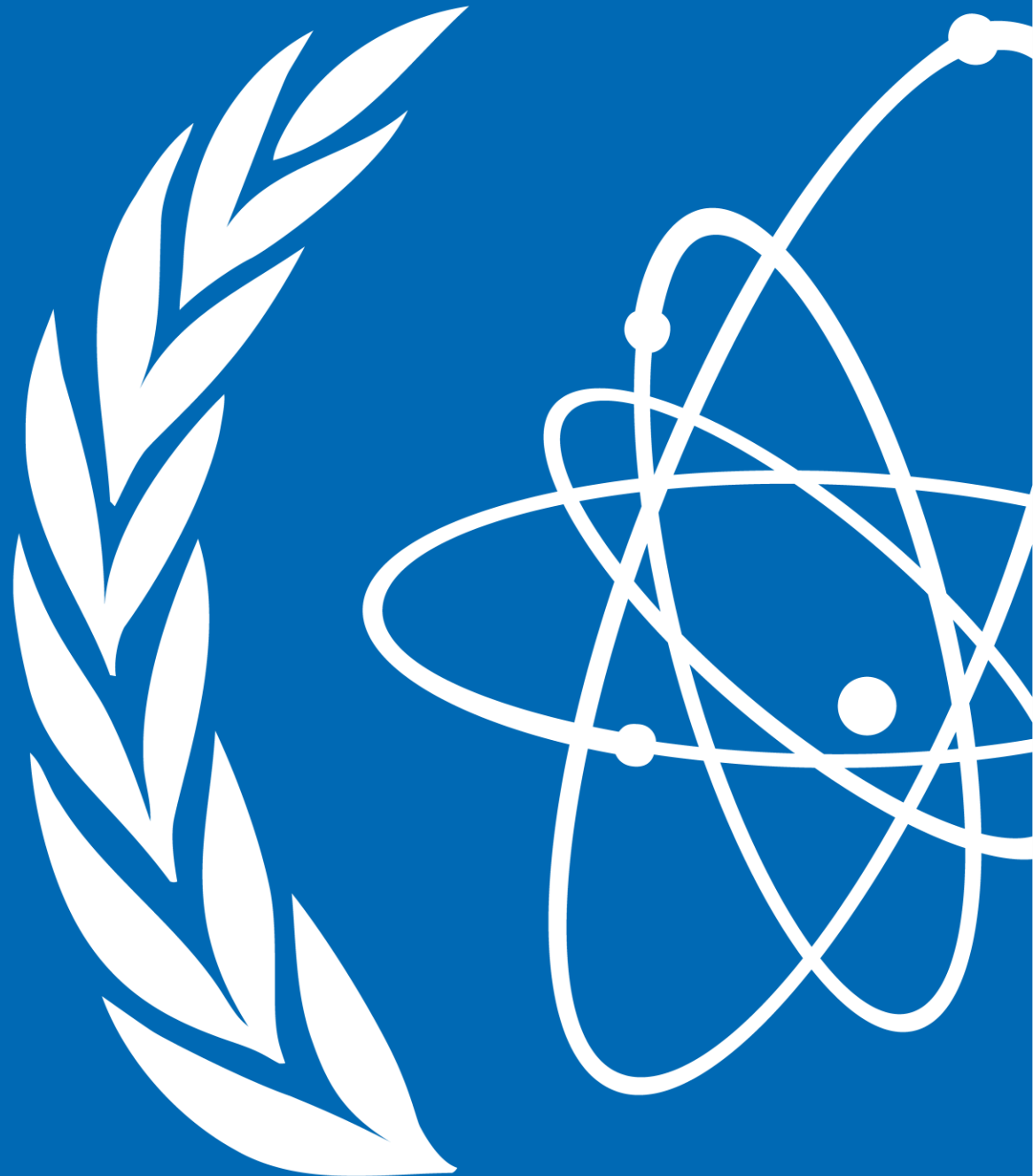
Status of Fuel Cycle Work at IAEA/NFCMS and INPRO

GIF Deep Dive on Fuel Cycles

Hainan, China

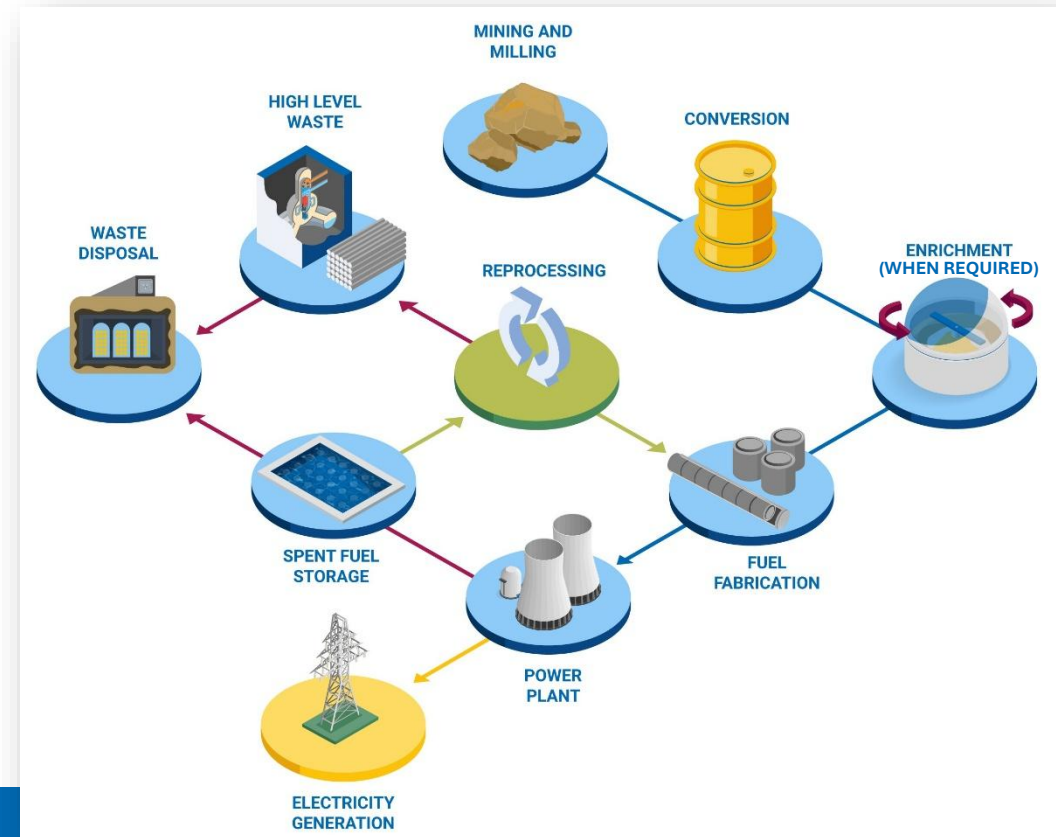
15 April 2026

Status of Nuclear Fuel Cycle Work in INPRO



INPRO and Advanced Nuclear Fuel Cycles

- ❖ Focuses on system level planning, rather than technology development
- ❖ Integrates reactors, fuel cycles and institutional arrangements
- ❖ Addresses institutional, legal, economic and societal drivers and impediments
- ❖ Evaluates the sustainability of innovative fuel cycles
- ❖ Supports national, regional and global energy strategies

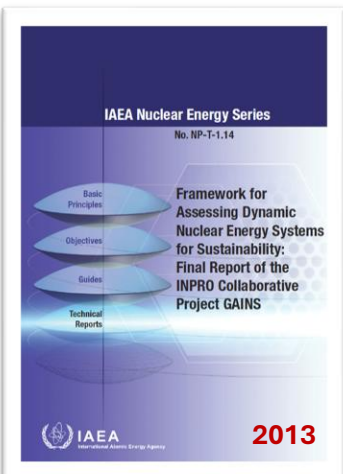


Advanced nuclear fuel cycles are a key element of INPRO work

Past INPRO Project on Advanced NFC

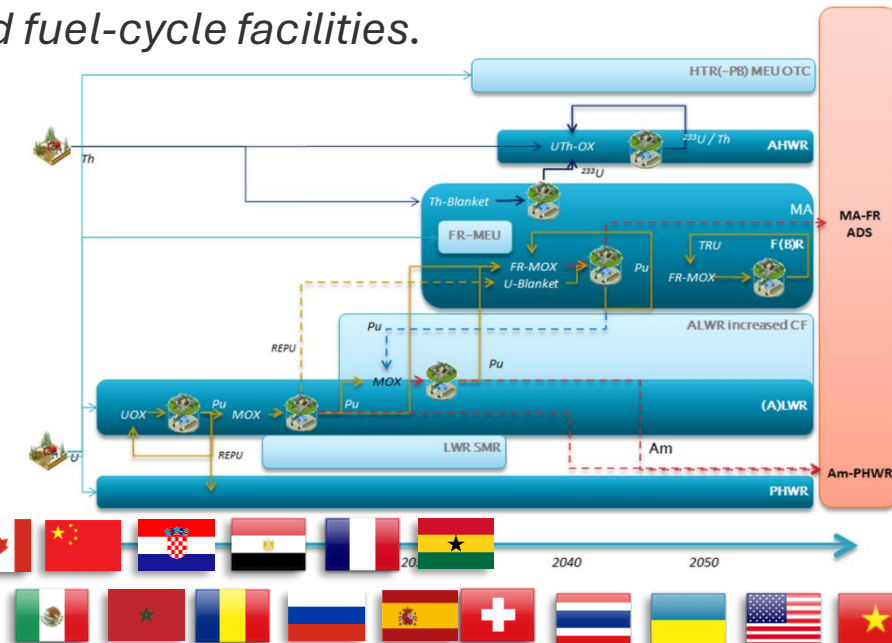
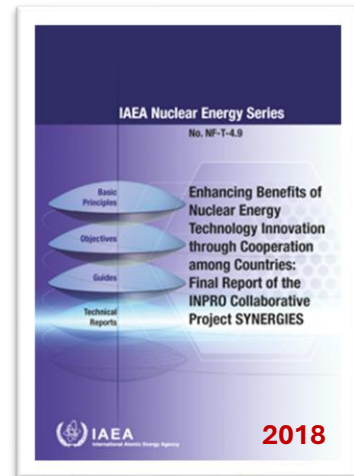
GAINS: Global Architecture of Innovative Nuclear energy Systems

- Based on thermal and fast reactors including a closed fuel cycle
- Developed a framework for long-term transition scenarios, introducing the concept of a heterogeneous world with differing fuel-cycle policies.



SYNERGIES: Synergistic Nuclear Energy Regional Group Interactions Evaluated for Sustainability

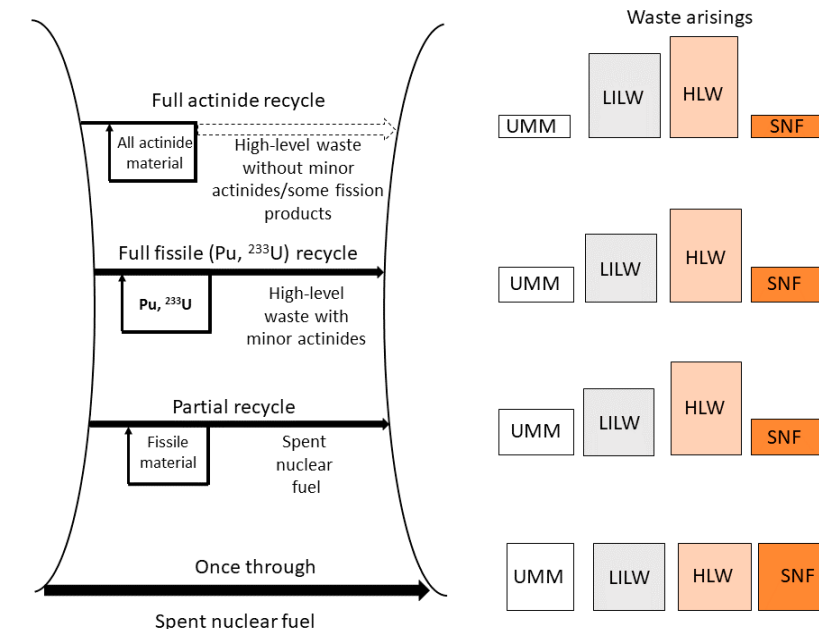
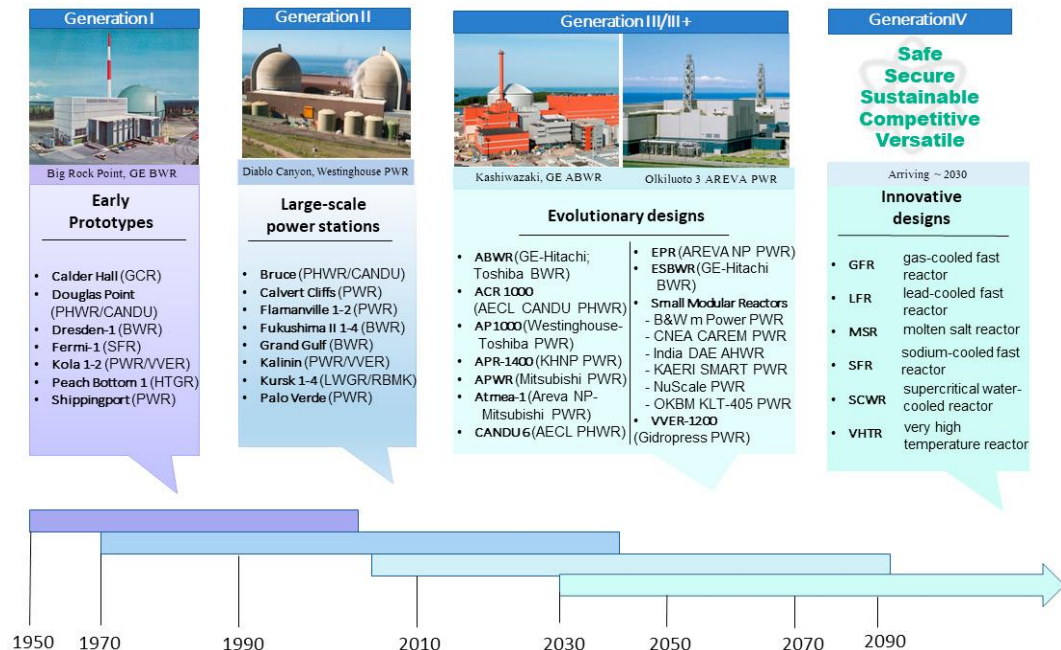
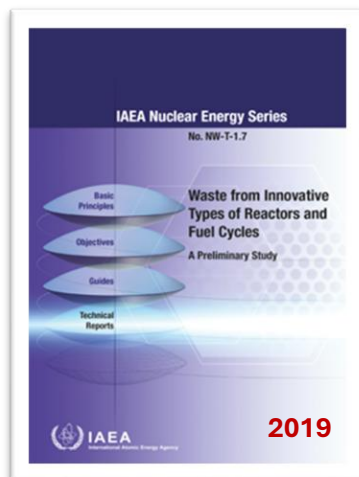
- Evaluated benefits of regional and international cooperation
- Identified “win-win” configurations
- Shared infrastructure options, particularly relevant for large-scale advanced fuel-cycle facilities.



WIRAF: Waste from Innovative Types of Reactors and Fuel Cycles



- ❖ Addressed **waste management challenges** from innovative reactors and fuel cycles
- ❖ Emphasising early integration of back-end considerations of **nontraditional waste streams** (e.g. fast reactors, advanced systems)
- ❖ Reinforced importance of back-end feasibility for sustainability



Current INPRO Project: STEP FORWARD

Building on GAINS, SYNERGIES and WIRAF

- ❖ Examines **integrated nuclear energy systems** combining thermal and innovative reactors
- ❖ Focuses on **reducing spent fuel inventories** and **improving fissile material utilisation**
- ❖ Assesses **transition pathways** from once-through to partially and fully closed NFC
- ❖ Considers **national, regional and cooperative deployment strategies**, including shared approaches
- ❖ Addresses **system-level sustainability implications**, complementing technology-specific studies
- ❖ Scope: 18 case studies by 13 MSs, in collaboration with NE Dept Sections (NPTDS, PESS, NEFW)



IAEA TECDOC SERIES

Potential of Innovative
Nuclear Installations
to Support Multi-
recycling of Fuel in a
Nuclear Energy
System

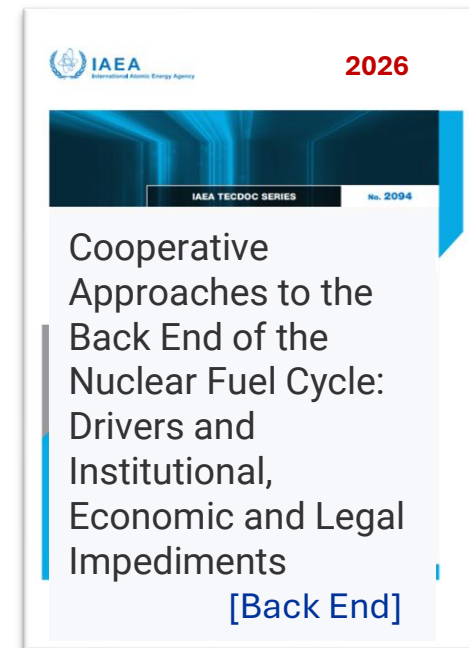
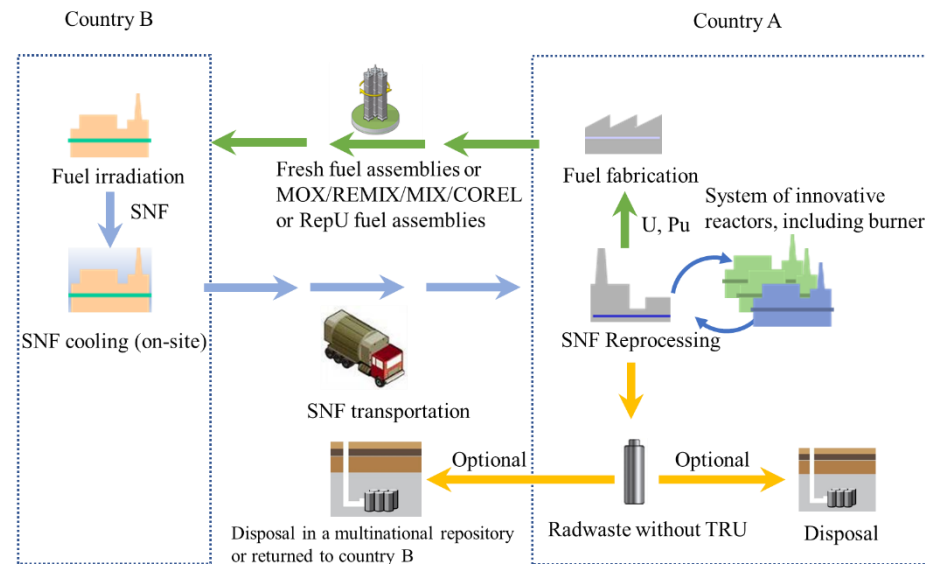
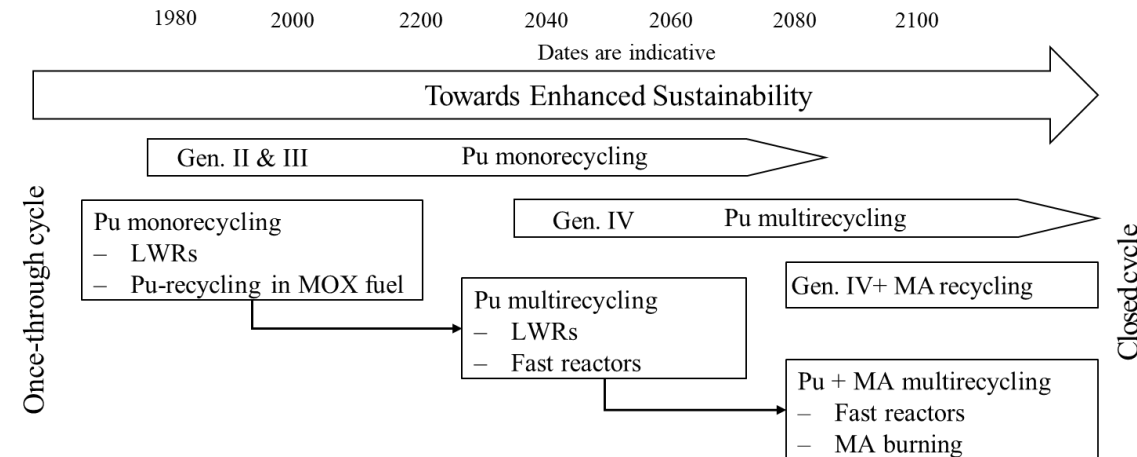
[STEP FORWARD]

Drafting

2026

Upcoming Publication: Collaborative Project on Back End

- ❖ Examines **international and regional cooperation** in spent fuel and waste management
- ❖ Considers **shared back end services**, including reprocessing, recycling, disposal and fuel take-back)
- ❖ Addresses **institutional, legal, economic and societal drivers and impediments**
- ❖ Demonstrates system-level benefits of cooperative approaches:
 - ✓ Cost reduction
 - ✓ Accelerated capability development
 - ✓ Improved public acceptability
- ❖ Highlights need for **robust governance, safeguards, and long-term sustainability**



TM: Proliferation Resistance Features of Fast Reactors and Associated Fuel Cycles

- ❖ Successfully convened an **international technical dialogue**, with strong **support from the GIF PRPPWG**
- ❖ Demonstrated the value of **system-level assessment of closed fuel cycles**, complementing technology-specific work in NEFW and NPTDS
- ❖ Strengthened understanding of links between **proliferation resistance, advanced recycling and back-end strategies**

INPRO provides a structured, system-level methodology to assess closed fuel cycles, complementing technology-specific work in NEFW and NPTDS.



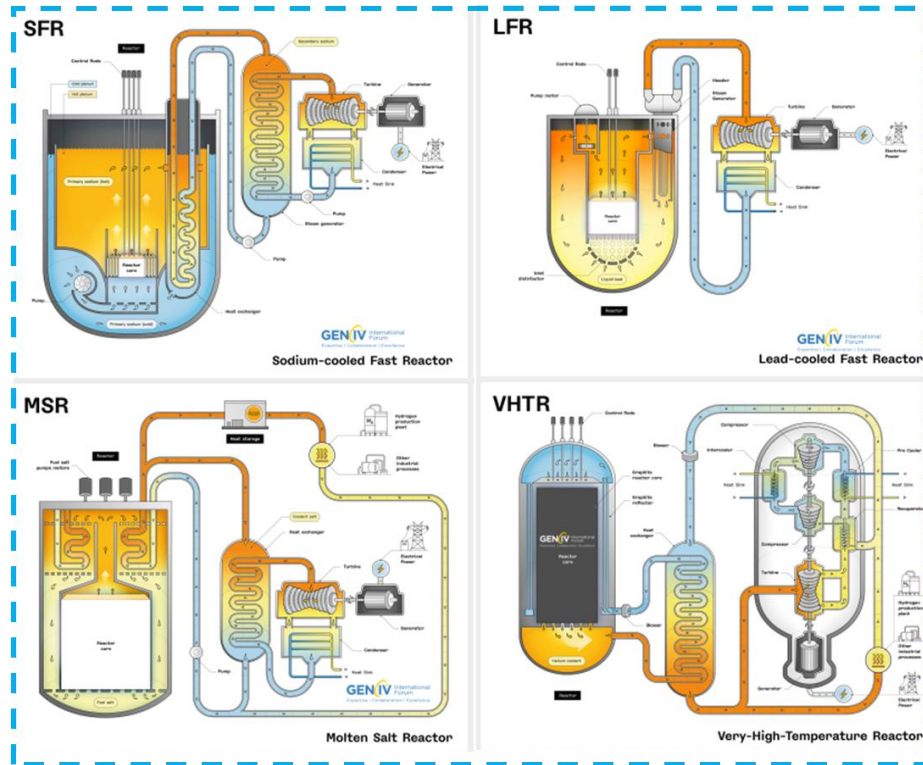
August 2025

Engaged: 32 participants from
29 Member States

IAEA's activities on fuel cycle options for GEN-IV reactors at Nuclear Fuel Cycle and Materials Section (NFCMS)



Which GEN-IV systems NFCMS works on?



NFCMS Publications on Fast Reactors Fuels and Fuel Cycle Options

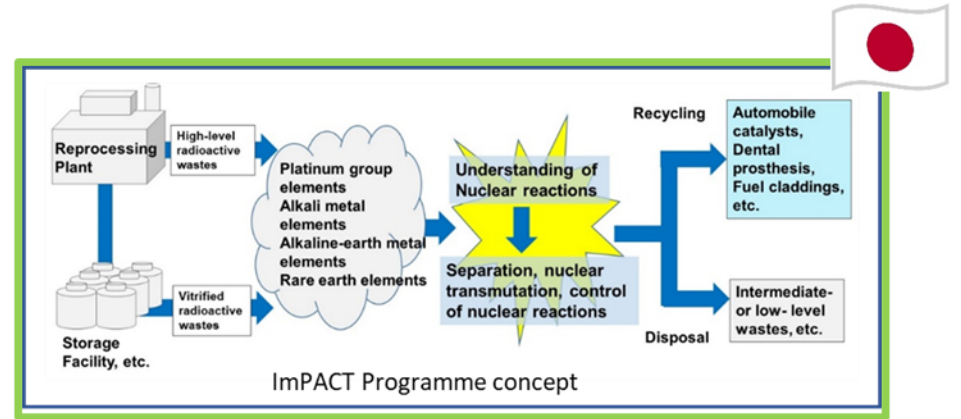


Coordinated Research Project T12031 (FMFR) on “Fuel Materials for Fast Reactors” (2019 - 2023)

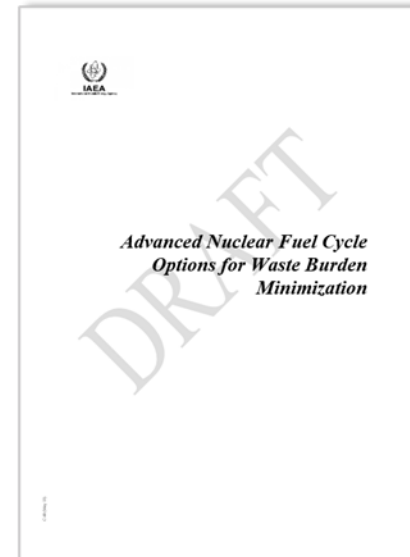
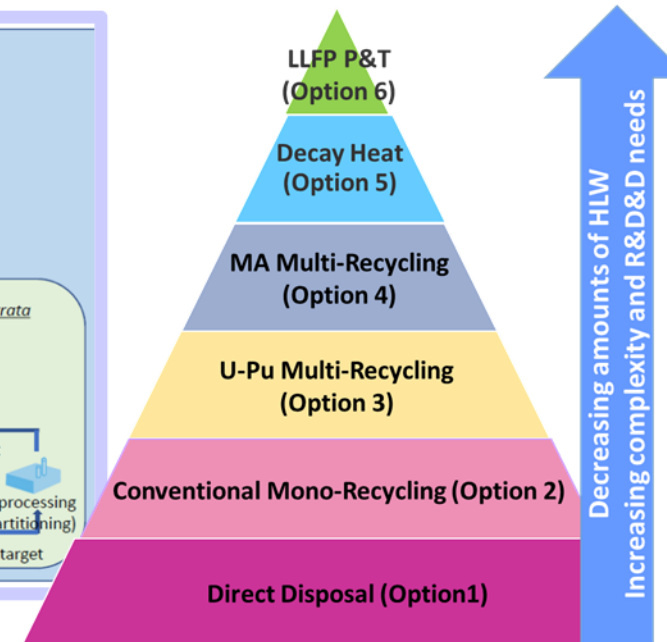
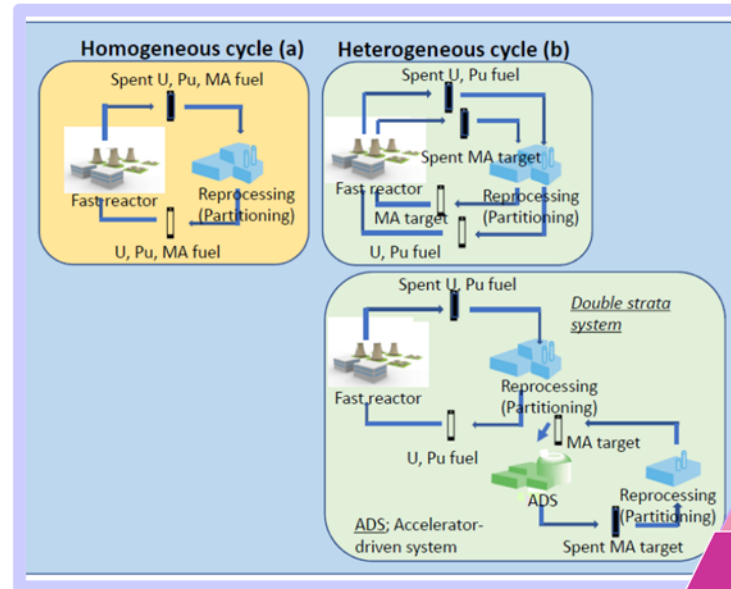
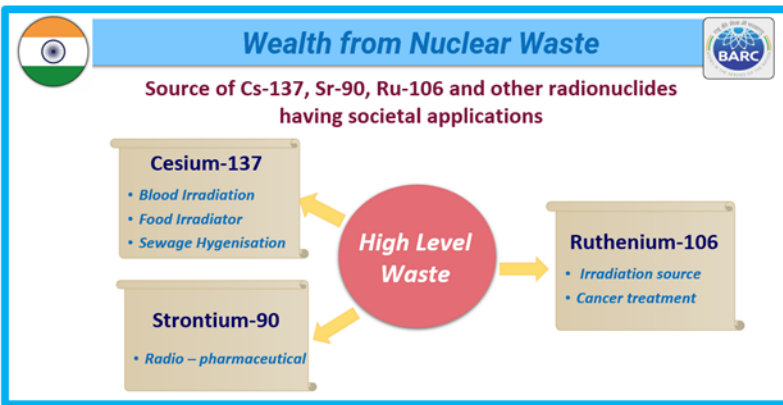
- To support the performance assessment of fuel and cladding materials of **sodium-cooled fast reactor technology**, in accordance with Gen-IV requirements, through enhancing fuel performance codes

Upcoming Publication: IAEA Report on Advanced Fuel Cycles

IAEA guidebook for Decision Makers on *Advanced Nuclear Fuel Cycle Options for Waste Burden Minimization and Natural Resources Preservation*
Describes relevant information on nuclear materials, generated wastes, nuclear facilities, infrastructures required, etc.



⚠️ LLFP impacting GDF: ^{79}Se , ^{99}Tc , ^{129}I , ^{135}Cs , ...



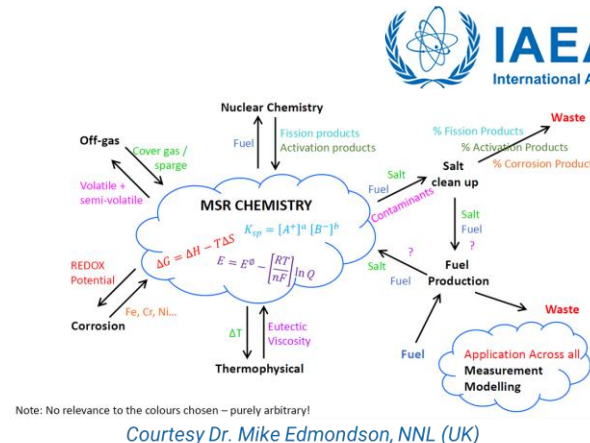
- **LWRs multirecycling**  
 - MIX and MOX-MR processes (France)
 - REMIX process (Russian Federation)
- **FRs multirecycling**

Activities related to Molten Salt Reactors Fuel Cycles

- **Joint IAEA-NEA Workshop on the Chemistry of Fuel Cycles for Molten Salt Reactor Technologies**, October 2023, Vienna
- **Joint IAEA-NEA-EC/JRC Workshop on the Taxonomy and Related Terminology of Fuel Cycles for Molten Salt Reactors**, November 2025, Vienna

- **Main elements** to develop a **taxonomy** for the fuel cycle options associated to MSR were identified.
- **List of terms related to MSR fuel cycles** and potential similarities (synonymous) identified.

Joint Publication under preparation



- **Workshop on Molten Salt Reactor Fuels: Recent Developments and Future Challenges**, July 2025, Vienna

- To exchange information on the cutting-edge research and perspectives on **MSR fuels salt synthesis processes** and **scaling up, packaging, purification technologies** for MSR fresh fuel salts, **characterization and qualification** of MSR fuel salt, **modelling and simulation** of fuel salt mixtures in-reactor behaviour.

IAEA Document in progress on *Spent HTGR Fuel Management and Differences and Similarities with Spent LWR-Fuel Management*

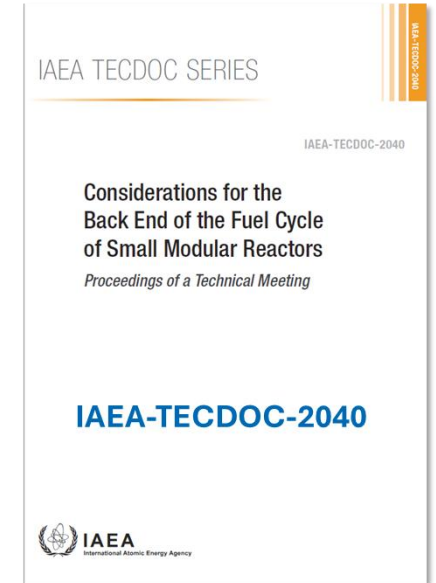
Coordinated Research Project on Challenges, Gaps and Opportunities for Managing Spent Fuel from SMRs (SMR-COGS) (2024 – 2028)

Understanding the implications of the management of new spent fuels is paramount to make informed decisions

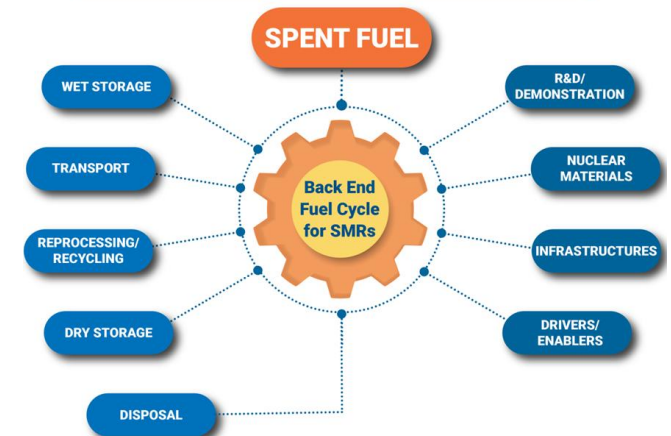
MAIN OBJECTIVES and OUTPUTS

Development of **specific roadmaps** for managing spent fuel from the different SMR technologies, identifying **what can be derived, optimized or adapted from existing practices, or what needs to be fully developed**

- **All SMR technologies included:** LWRs (LEU, LEU+, HALEU), HTGR (TRISO (compact, pebbles)), FRs (Metallic, Oxide, Nitrides, ...), MSRs
- **To compare various SMR systems**, in terms of efforts required to develop and implement an SFM strategy

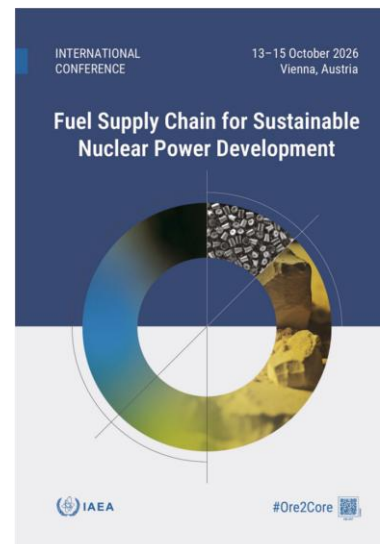
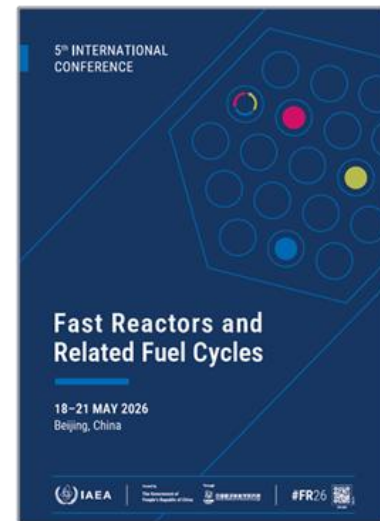


IAEA SMR-COGS Project



Upcoming NFCMS' Events on Advanced Nuclear Fuels and Fuel Cycle Options

1. International Conference on Fast Reactors and Related Fuel Cycles (FR26), **18-21 May 2026, Beijing, China**
2. International Conference on Fuel Supply Chain for Sustainable Nuclear Power Development, **13-15 October 2026, Vienna**
3. Workshop on the Current Status of Structural Material Development for Molten Salt Reactors and Related Challenges, **20 – 24 July 2026, Vienna**
4. Technical Meeting on Digitalization and the Use of Artificial Intelligence in Advanced Nuclear Fuel Manufacturing and Quality Control, **27 – 31 July 2026, Vienna**
5. Technical Meeting on Policy and Strategies for Spent Fuel and Radioactive Waste Management, **16 – 20 November 2026, Vienna (In collaboration with Waste Technology Section)**
6. Workshop on Nuclear Fuel Cycle Options for Current and Advanced Reactors, **08-11 December 2026, Vienna, Austria**



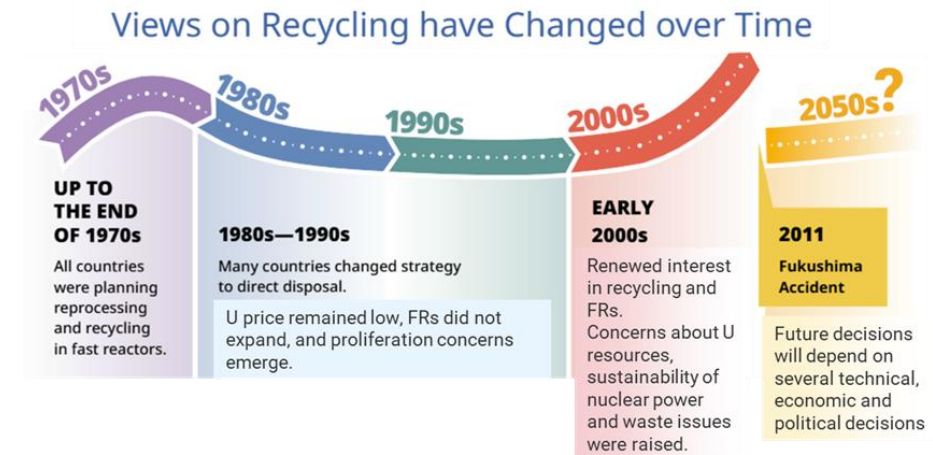
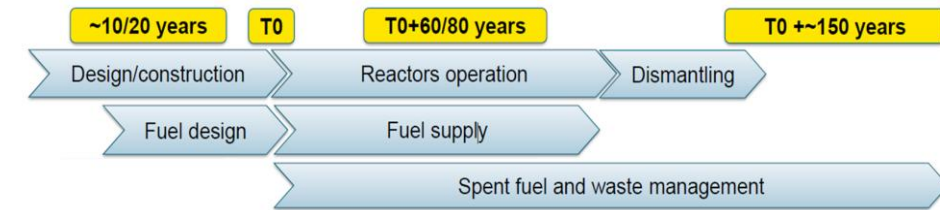
New Activity on Enhancing Resilience in the Backend of the Fuel Cycle

*Proposed by the Technical Working Group on Nuclear Fuel Cycle Options and Spent Fuel Management (TWG-NFCO)
March 2026*

Main Objectives:

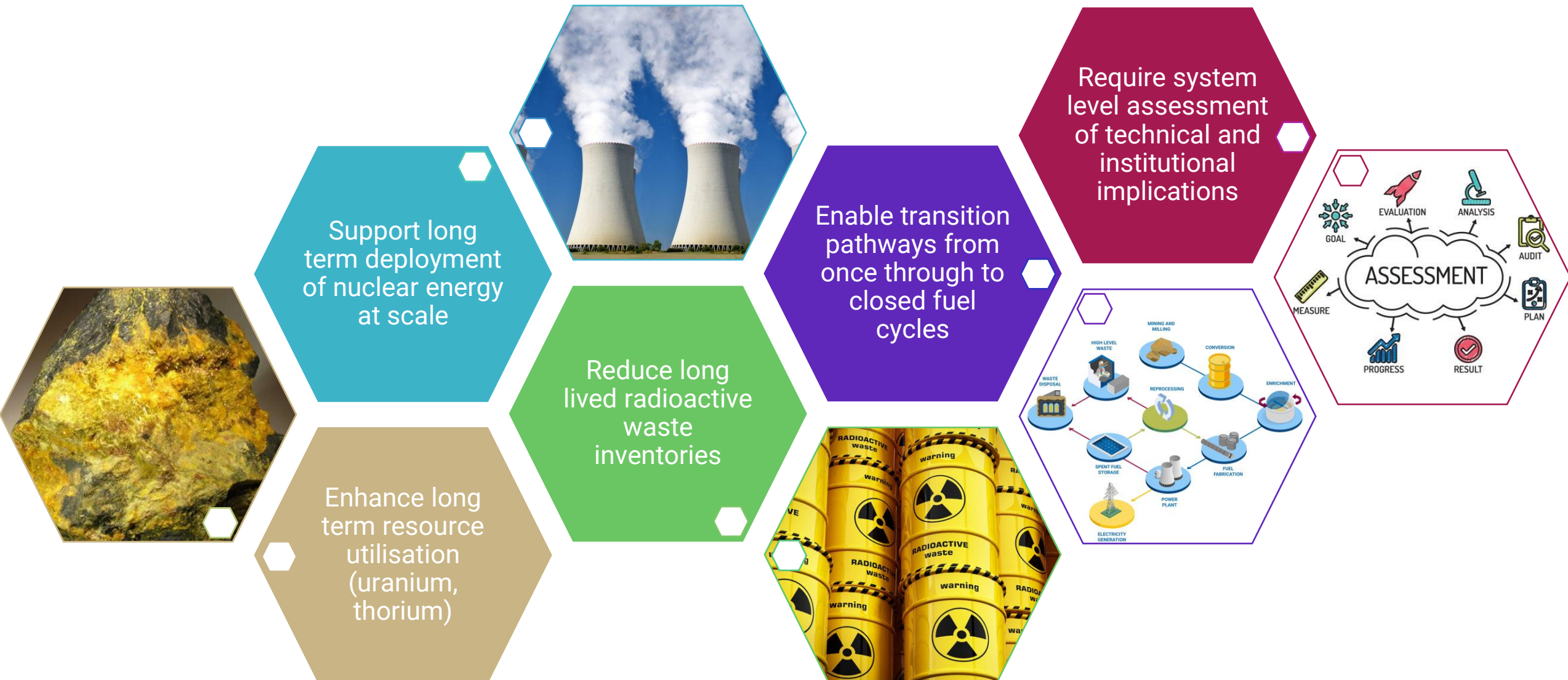
- Compile lessons learned on transitions in Spent Fuel Management Strategies for the **last 70 years of Nuclear Energy deployment**, to identify main aspects that provide resilience.
- Explore **potential collaborative approaches** for Managing Spent Fuel in an expanding Nuclear Energy environment by 2050, including shared infrastructures, commercial services, partnerships, learning from Front End activities.
- **IAEA activity implemented through internal collaboration:**
 - Nuclear Fuel Cycle and Materials Section
 - INPRO Project
 - Waste Technology Section

A joint Technical Meeting on the topic is planned



Role of Advanced Fuel Cycles in Sustainability

Transforming waste into long-term assets for sustainable nuclear energy





IAEA

Thank You
