IAEA
International Atomic Energy Agency
Atoms for Peace and Development

IAEA Ongoing Activities on Nuclear Fuel Cycle Options and Spent Fuel Management

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EURAD Lunch&Learn Webinar, 28 June 2023

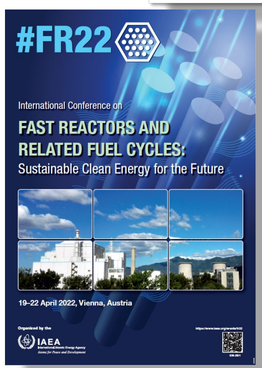
ARTICLE II: Objectives

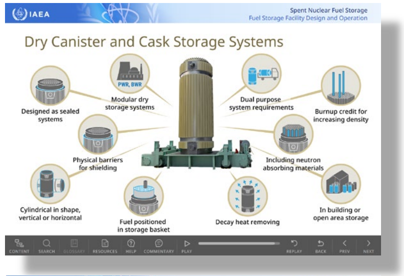
“The Agency shall seek to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world. It shall ensure, so far as it is able, that assistance provided by it or at its request or under its supervision or control is not used in such a way as to further any military purpose”

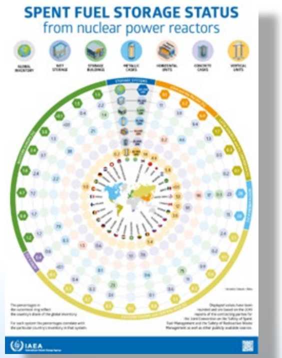
ARTICLE III: Functions

“The Agency is authorized …To foster the exchange of scientific and technical information on peaceful uses of atomic energy [and] To encourage the exchange and training of scientists and experts in the field of peaceful uses of atomic energy”

- Through:
  - Technical Meetings and publication of technical documents and reports
  - The coordination of international research activities through Coordinated Research Projects (CRPs)
  - International conferences and workshops
  - E-Tools; Outreach Materials





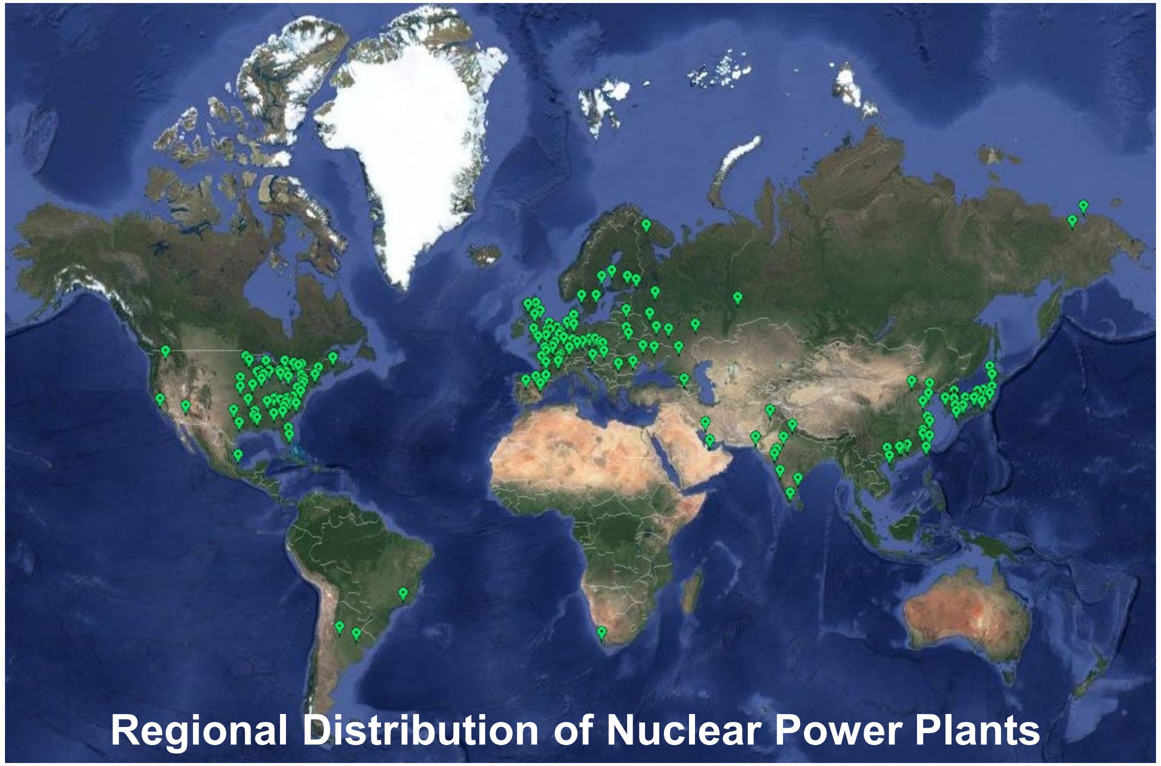


Outline

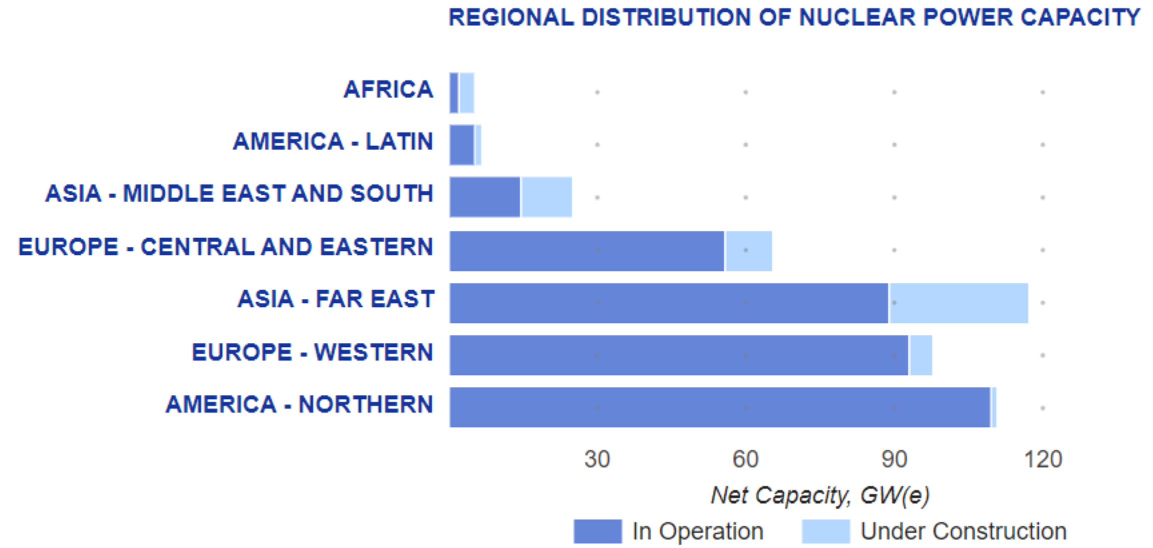
- Overview of Spent Fuel Management and Current Challenges

- IAEA Ongoing Activities:
  - Recent Meetings and Ongoing Publications
  - Coordinated Research Projects (CRPs)
  - International Conferences
  - Outreach and Dissemination Materials

Current Worldwide Situation of Nuclear Power



410 nuclear reactors operating in **31** countries



57 more reactors under construction
~2/3 in Asia

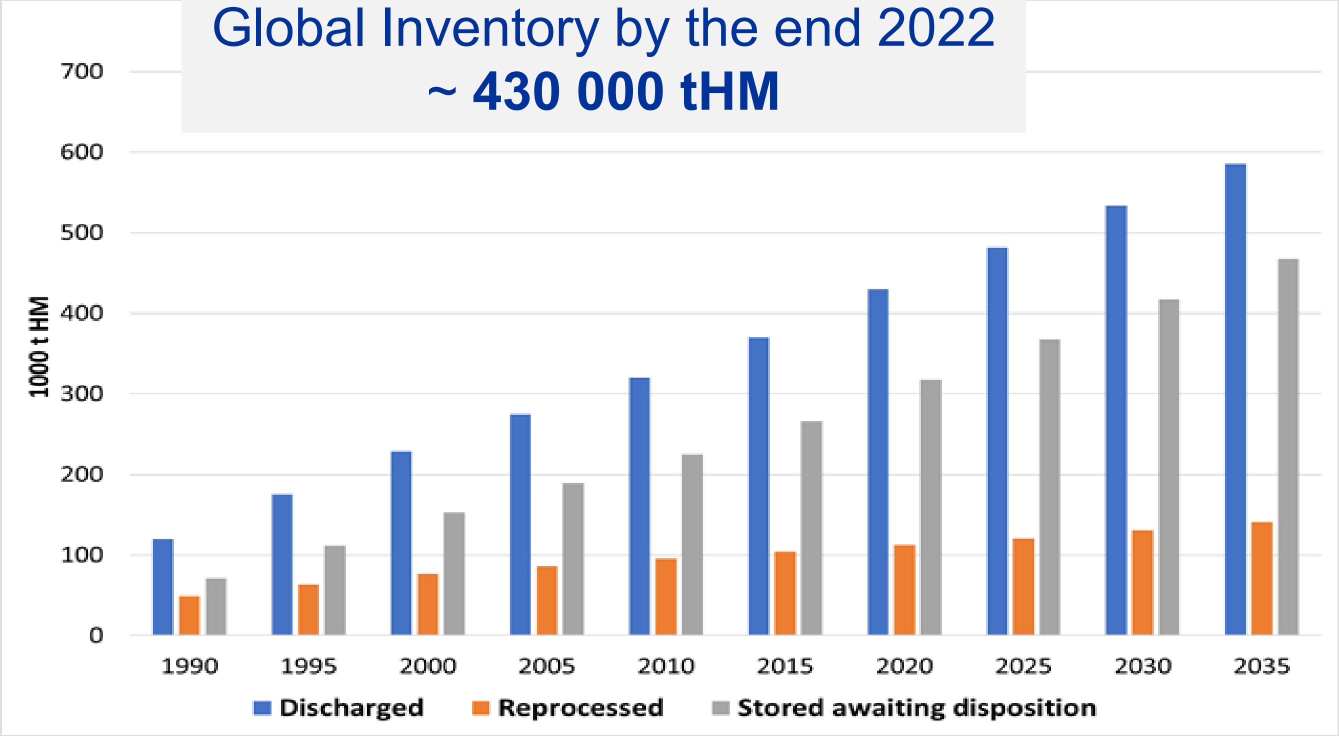
~30 new countries planning or developing a nuclear power programme

Over 10% of global electricity; $^1/_4$ of low-carbon electricity

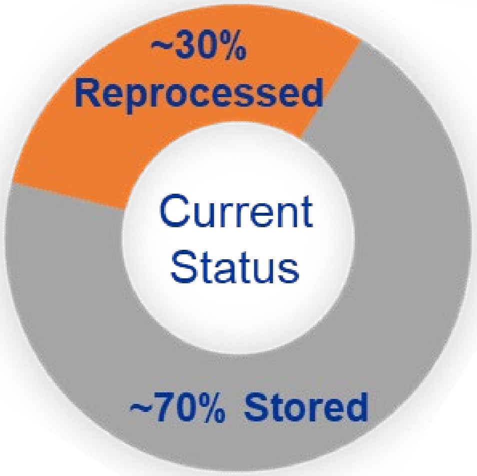
From IAEA-PRIS Information System

Spent Fuel Management: Status and Trends

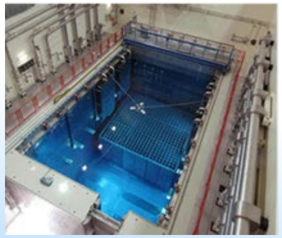
Global Inventory by the end 2022
~ 430 000 tHM



Annual Discharge ~ **10 000 tHM**



Global Inventory in storage by the end 2022
~ 301 300 tHM



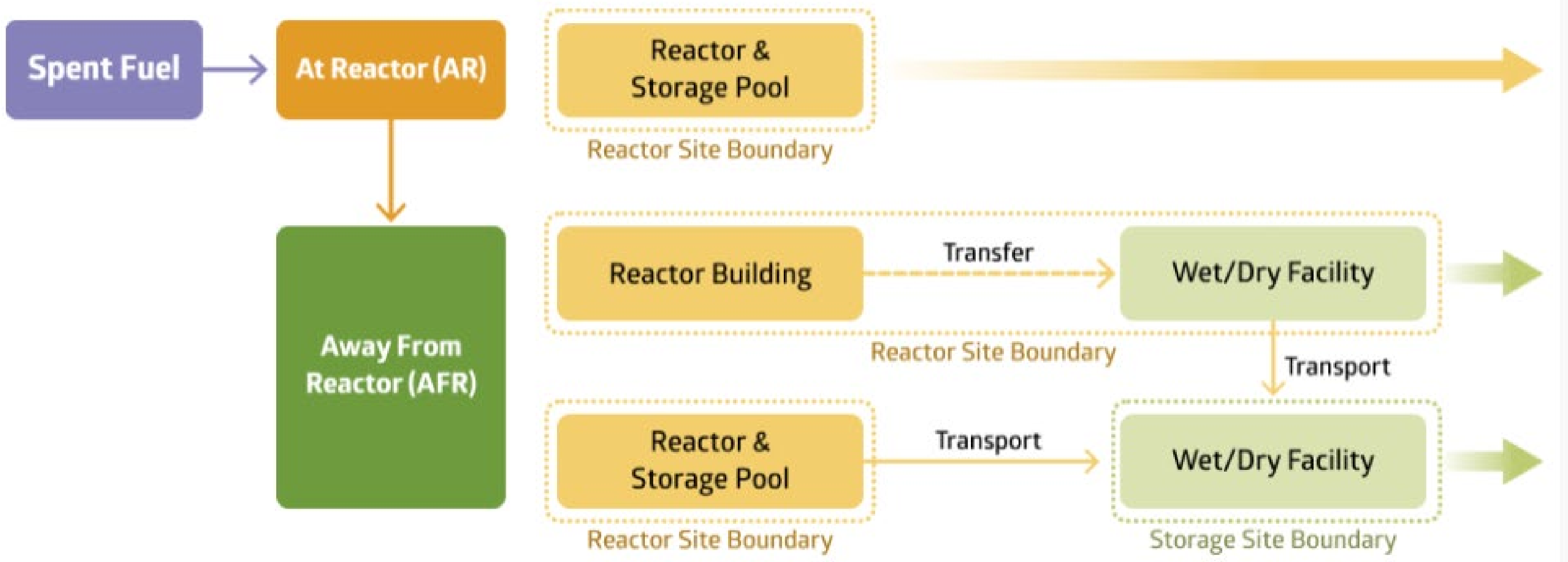
Selection of storage technology depends on many factors

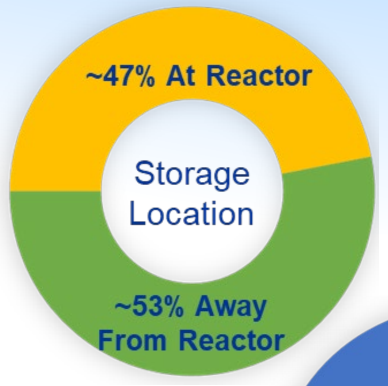
The type of fuel being stored

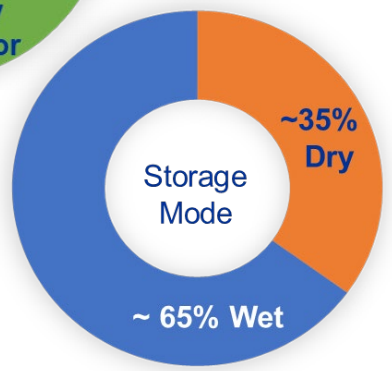
Economic factors

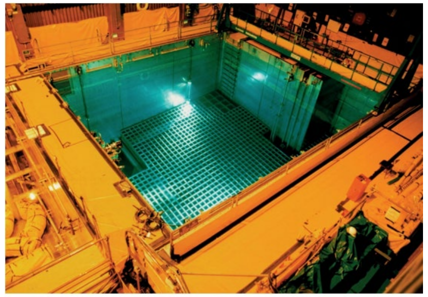
Preferences of operator, stakeholders, public, etc.

Spent Fuel Storage Strategies Leading to Future Disposition









Spent fuel pool at the San Onofre, San Clement, CA, (USA)

Dry storage at José Cabrera NPP (Spain)

On-site
Transfer

Wet storage (Tihange NPP, Belgium)

CLAB Wet Storage Facility – Sweden

Off-site
Transport

Zwilag (Switzerland)

Spent fuel management current situation worldwide

Today mainly countries with large nuclear power programmes recycle spent fuel: France, the Russian Federation, Japan, India and China.

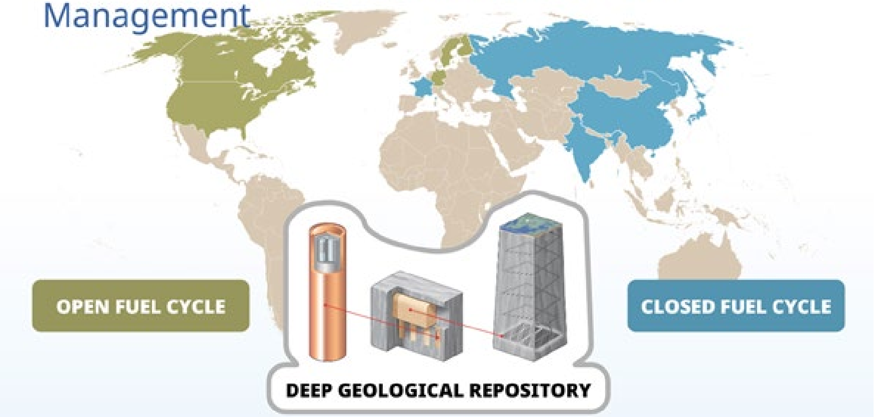
Some countries have not yet made a final decision.

Most spent fuel is in interim storage.

Several other countries have opted for direct disposal: Finland, Sweden, Canada, Germany, Switzerland

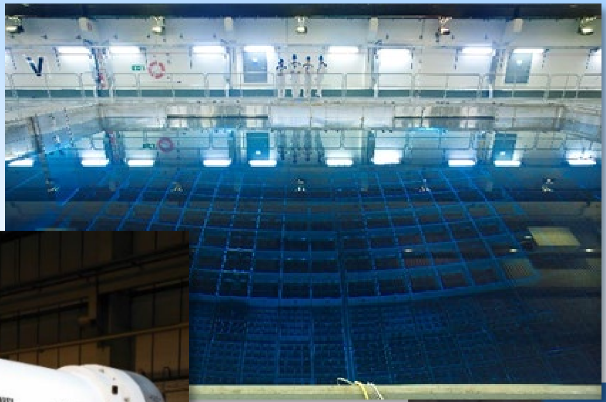
Netherlands reprocesses SF from Borssele NPP abroad and stores High Level Waste at HABOG facility

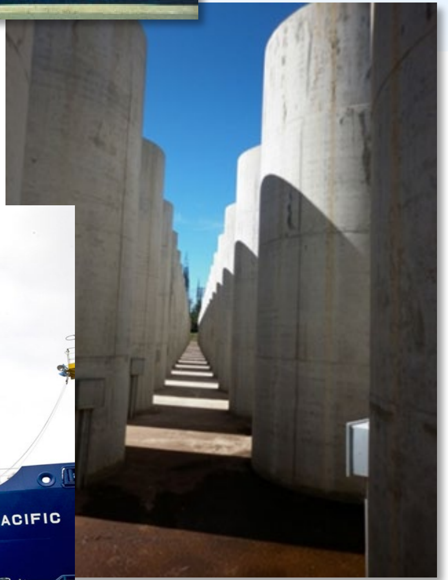
Strategic Options for Spent Nuclear Fuel Management

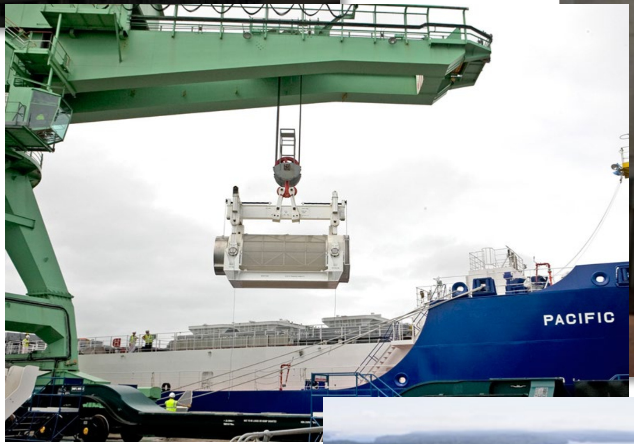


Challenges in Spent Fuel Management

- Planned storage durations are increasing:
  - In 1980s 20-50 years
  - In 1990s up to 100 years
  - In 2000s 100+ years
- License renewal for storage systems
- Confirming ongoing SNF behaviour & integrity
- Maintenance and inspection of SSCs
- Ageing management (beyond design basis for most)
- Transportability after long storage durations and orphan sites
- Implement multi-recycling in LWRs at industrial scale
- Demonstrate and scale up multi-recycling through Advanced Fuel Cycles for innovative reactors
- Accommodate new SNF from SMR different types
- Successful implementation of DGRs







Yankee Rowe NPP (USA)

Outline

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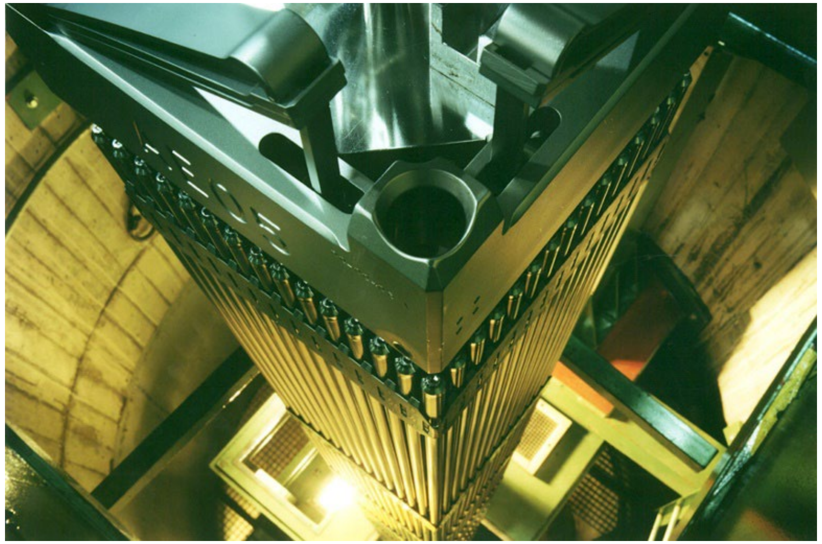
Technical Meeting to Identify Opportunities and Challenges in the Backend Steps of Fuel Cycles Based on Evolutionary Accident Tolerant Fuels (eATFs), 14-16 June 2022 (Virtual)

- **Focused on ATFs mature enough to commence fuel qualification and near term deployment in existing reactor fleet**
  - Coated cladding oxides and dopants
- Lot of work underway to understand the impact and more activity is needed to understand the key questions
  - Relatively few major concerns identified, recognizing currently only limited data
- **Importance of multilateral cooperation was highlighted**
  - Loss of Halden test reactor further limits resources for materials irradiation testing
  - Limited data at present means sharing materials, data and results prevents rework and represents a more cost effective approach

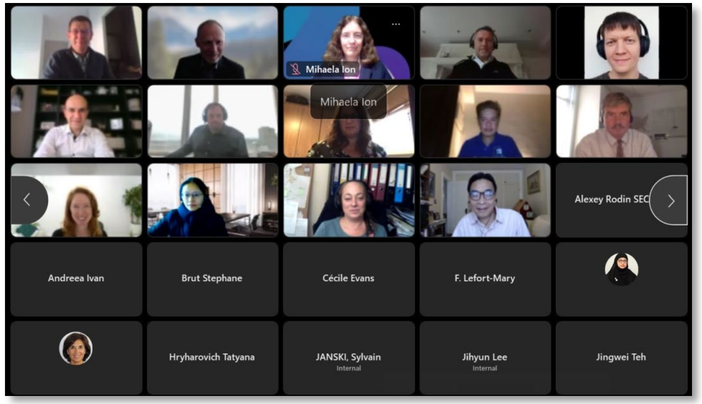


33 experts from 16 Member States and 1 International Organization

IAEA Technical Meeting on Backend of the Fuel Cycle Considerations for Small Modular Reactors, 20-23 September 2022

107 Participating Experts from
32 Member States and **3** International Organizations

~ 40 Presentations and Extended Abstracts



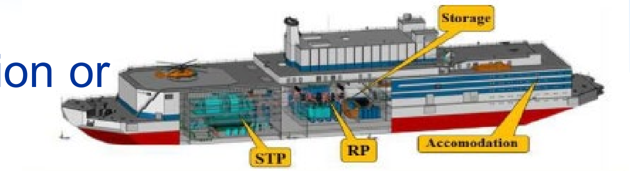
IAEA-TECDOC approved for internal review

Compiled material and Meeting Report publicly available here

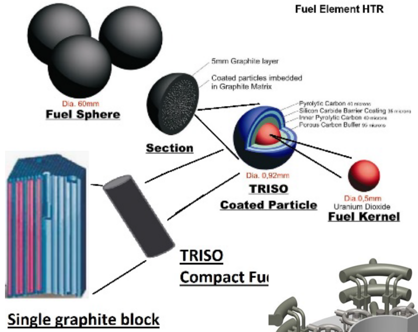
[Technical Meeting on Back End of the Fuel Cycle Considerations for Small Modular Reactors (20-23 September 2022): Overview · Indico for IAEA Conferences (Indico)]

Main Challenges for SMR Spent Fuels

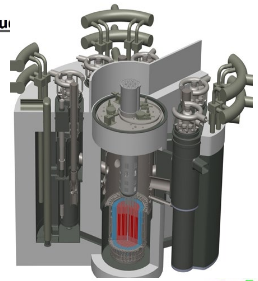
- LWR-type SMRs (Land based): Enrichment levels of below 5% and similar Burnups to conventional PWRs
  - Transport and storage solutions for smaller fuel assemblies will require recertification or new developments are needed



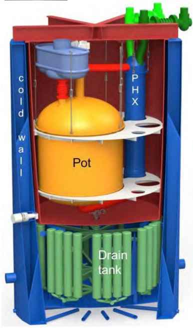
- LWR-type SMRs (Marine based): Enrichment levels up to 20% (HALEU), higher Burnups
  - Different radionuclides composition and higher thermal outputs
  - Necessary code validation in order to do e.g. decay heat calculations



- HTGR-type SMRs: Pebble Beds/Prismatic. Limited Backend Experiences
  - Main challenge remains the disposability of irradiated graphite



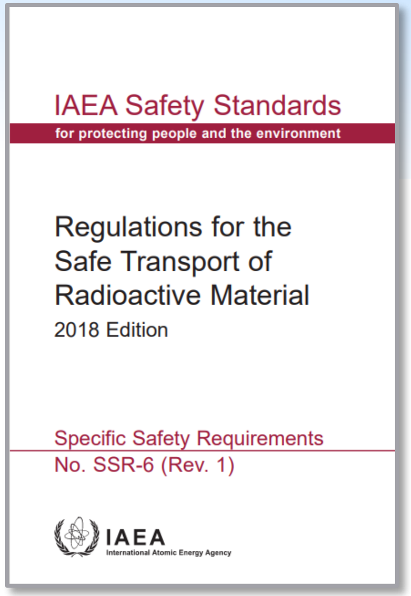
- Liquid-Metal-Cooled Fast Neutron SMRs: New fuel types introducing a new spent fuel characteristics/multirecycling processes



- Molten Salt SMRs: Nuclear fuel dissolved in melted chloride/fluoride fuel salts. Recycling of fissile material and managing salt mixtures containing all fission products is a challenge

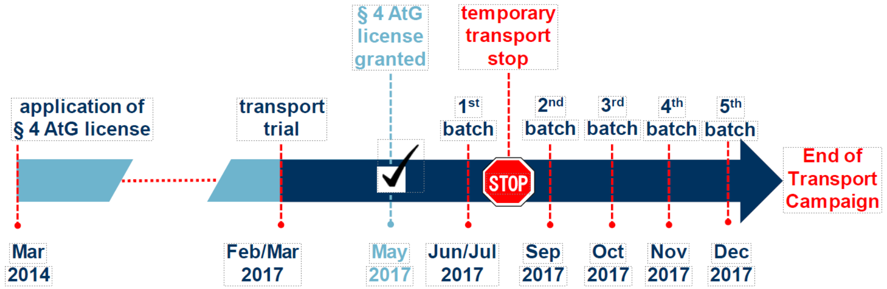
Transportation Considerations

- For fresh fuel elements some existing packages may be utilised for enrichments up to 10% with additional modifications
- Some SMR concepts are planning a centralized manufacturing of the whole SMR, instead of construction at the site of operation, including loading the fuel
- The SMR would most likely act as a package
- Transportable SMRs
- Potential transport would have to fulfil all transport requirements
- Regulations described in SSR-6 (Rev.1) would apply and might have an impact on the SMR design



Technical Meeting on Operational Experiences on Spent Fuel and High Level Waste Transportation, 17-21 October 2022

- Spent fuel has been regularly transported for decades
- TM reviewed draft TECDOC on Operational Experience containing case studies from seven countries and suggested some structural changes

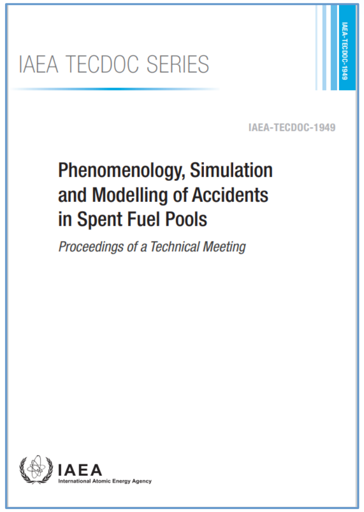


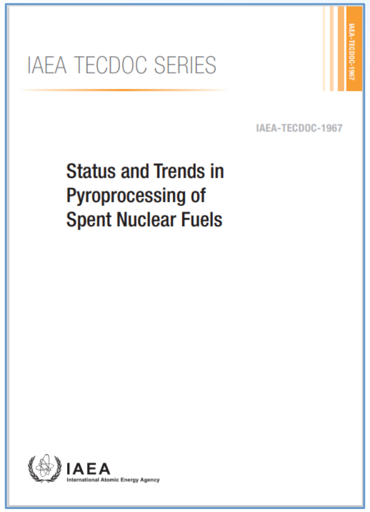
Detailed regulations require long preparation times

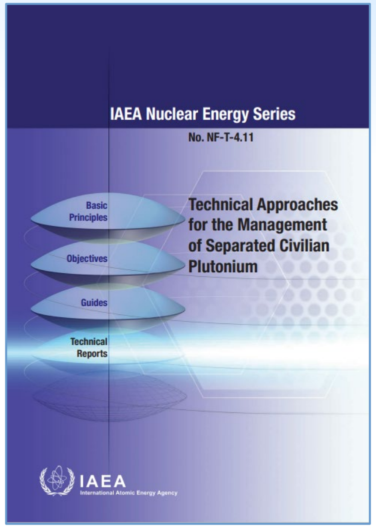
40 participants from 16 Member States and 3 International Organizations

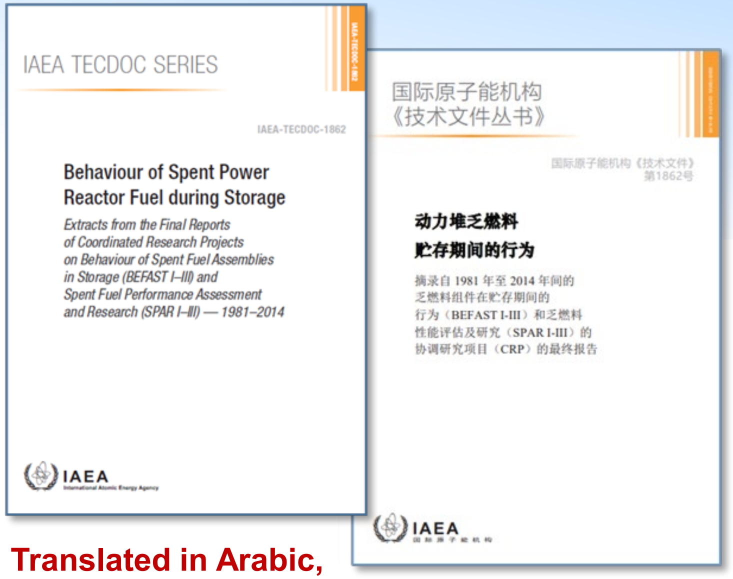
Recent IAEA Publications on Spent Fuel Management

Translated in Arabic, Chinese and Russian



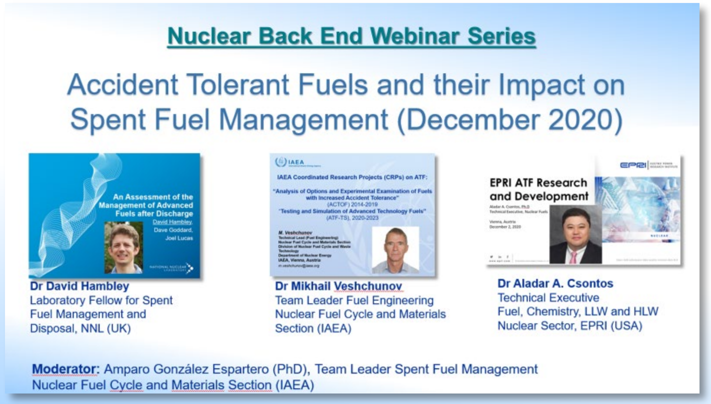






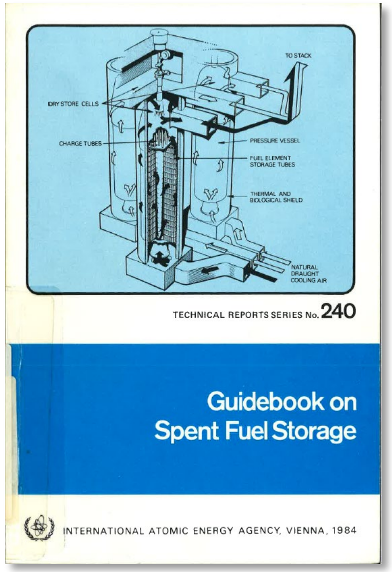
Translated in Arabic, Chinese & Russian

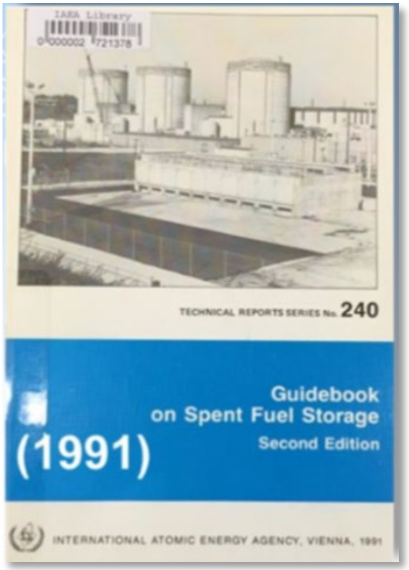
IAEA Webinars Spent Fuel Management



IAEA Guidebook on Spent Fuel Storage Options and Systems, 3rd Edition

HARD COPY ONLY





Technical Reports Series No. 240

Guidebook on Spent Fuel Storage Options and Systems

Third Edition

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IAEA Report DOC

IAEA Safety Standards

IAEA Safety Standards
for protecting people and the environment

Regulations for the Safe Transport of Radioactive Material
2018 Edition

Specific Safety Requirements
No. SSR-6 (Rev. 1)

IAEA
International Atomic Energy Agency

IAEA Safety Standards
for protecting people and the environment

Storage of Spent Nuclear Fuel

Specific Safety Guide
No. SSG-15 (Rev. 1)

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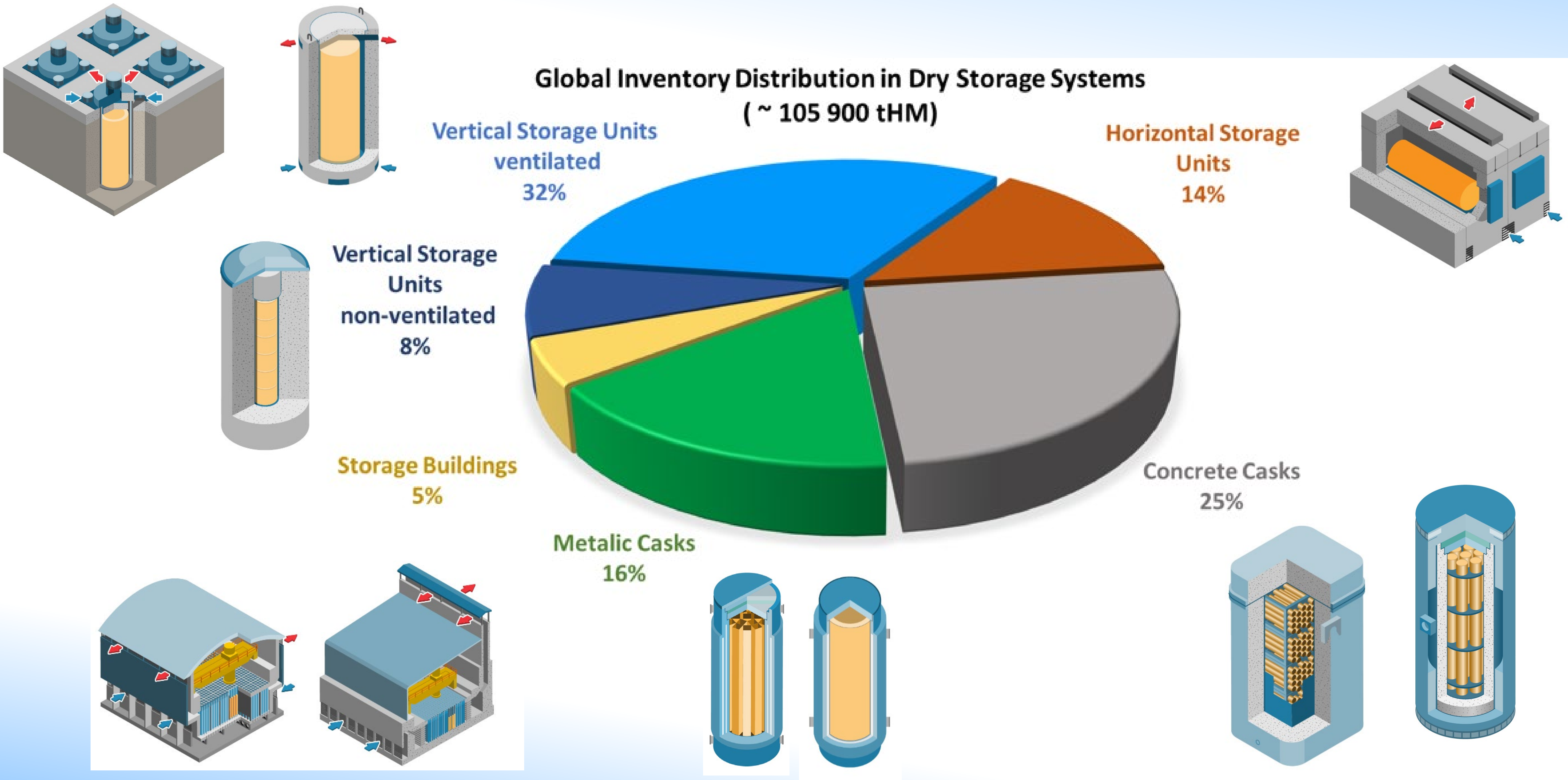
International Atomic Energy Agency

Planned storage durations are increasing:

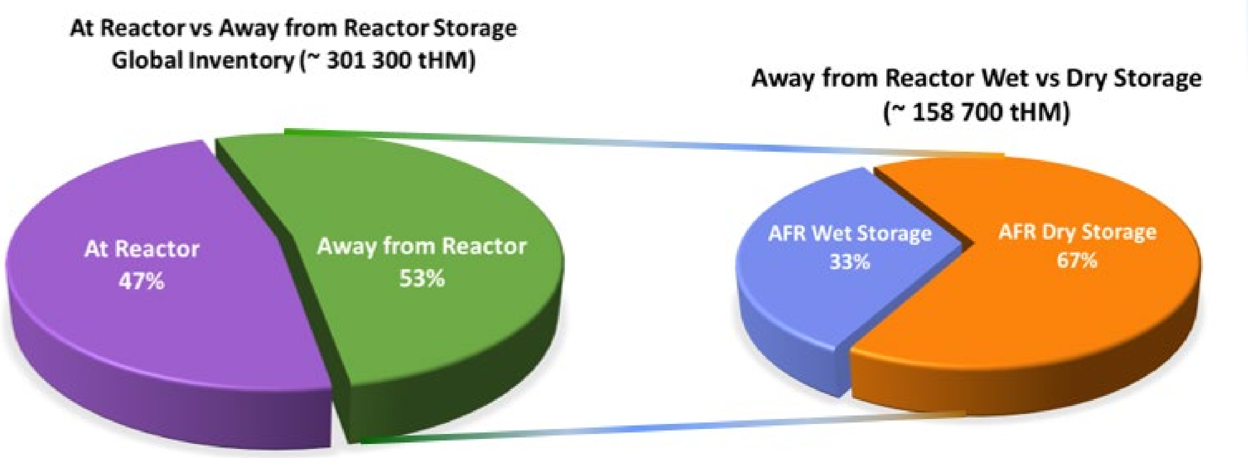
- In 1980s 20-50 years
- In 1990s up to 100 years
- In 2000s 100+ years

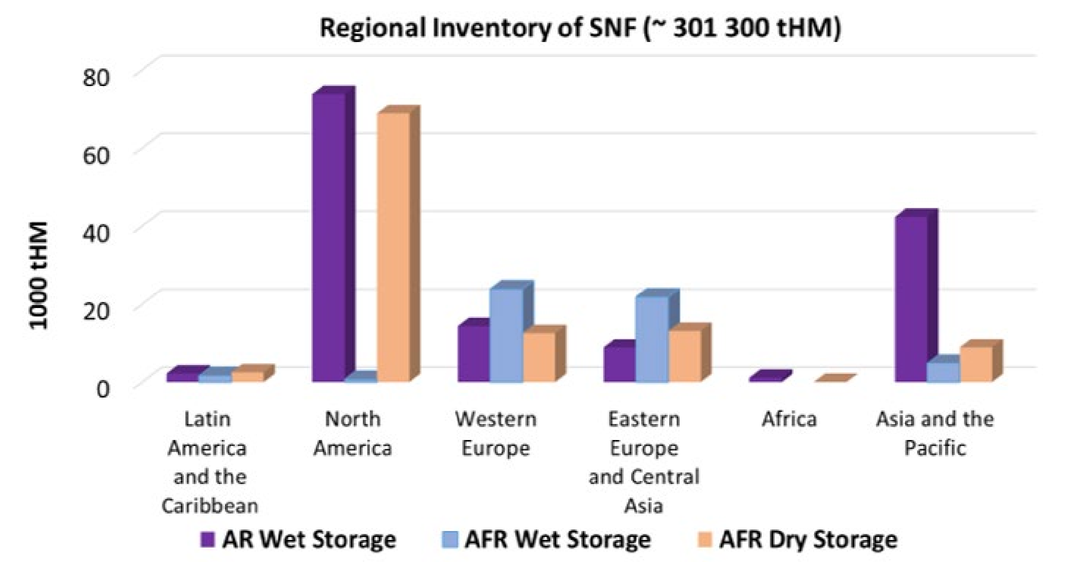
Ageing management of deployed storage systems is paramount to ensure safety functions and transportability

Dry Storage Technologies

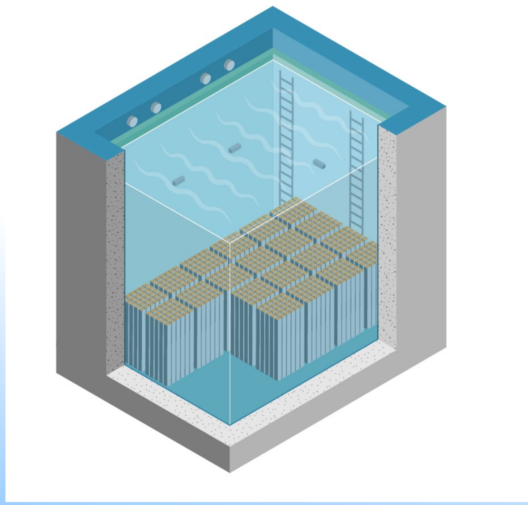


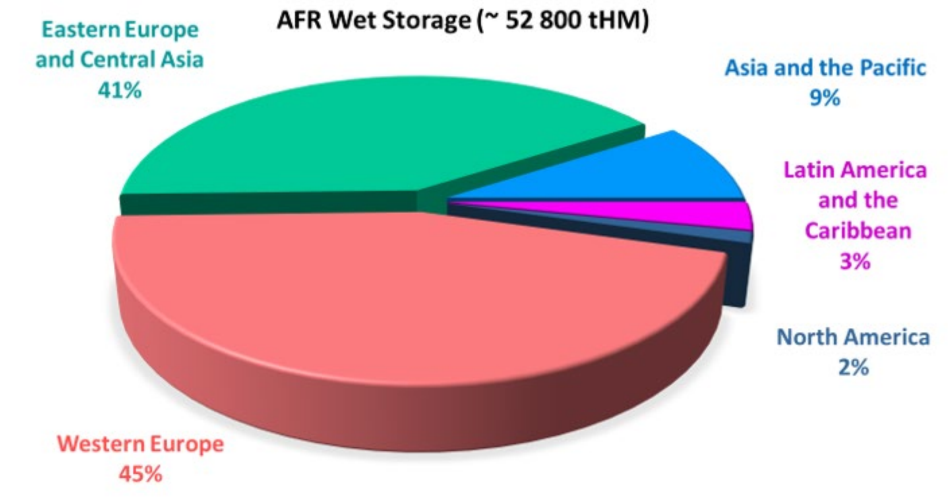
Distribution of Spent Fuel Inventory under Storage Worldwide





Wet Storage Technology





Additional Resources (IAEA related publications and Glossary)

IAEA

Content of the Guidebook

APPENDIX V. SPENT FUEL STORAGE RELATED IAEA PUBLICATIONS

This Appendix provides a summary of the publications produced within the IAEA related to spent fuel storage (Table 11).

TABLE 11. LIST OF SPENT FUEL STORAGE RELATED PUBLICATION PRODUCED WITHIN THE IAEA.

Area/Reference	Scope
Spent fuel storage	
International Atomic Energy Agency, Storage, Handling and Movement of Fuel and Related Components at Nuclear Power Plants, Technical Reports Series No. 189, IAEA, Vienna (1979).	This technical report describes in general terms the various operations involved in the handling of fresh fuel, irradiated fuel, and core components such as control rods, neutron sources, burnable poisons and removable instruments. It attempts to outline the principal safety problems in these operations and provides the broad safety criteria which must be observed in the design, operation and maintenance of equipment and facilities for handling, transferring, and storing nuclear fuel and core components at nuclear power reactor sites.
International Atomic Energy Agency, Storage of Water Reactor Spent Fuel in Water Pools, Technical Reports Series No. 218, IAEA, Vienna (1982).	This publication summarizes the results of a survey conducted by the IAEA and the Nuclear Energy Agency (NEA) of the Organization for Economic Cooperation and Development (OECD) on the wet storage experiences of water reactor fuel among countries with operating nuclear power programmes. The responses represented over 85% of the water-cooled power reactor pools and away-from-reactor pools that have operated for 5 years or more. Responses from research reactor pools and facilities that store gas reactor fuel were also included.
Safety Standards, Guides, and Reports (Storage and Transportation)	
International Atomic Energy Agency, Fundamental Safety Principles, Safety Fundamentals, Safety Standards Series No. SF-1, IAEA, Vienna (2006).	This publication states the fundamental safety objective and ten associated safety principles, and briefly describes their intent and purpose. These are applicable, as relevant, throughout the entire lifetime of all facilities and activities, including spent fuel storage, existing and new, utilized for peaceful purposes, and to protective actions to reduce existing radiation risks.

GLOSSARY

ageing management*
Engineering, operations and maintenance actions to control within acceptable limits the ageing degradation of structures, systems and components.
Examples of engineering actions include design, qualification and failure analysis. Examples of operations actions include surveillance, carrying out operating procedures within specified limits and performing environmental measurements.

at-reactor (AR) storage facilities
A storage facility (pool) co-located with the reactor, inside the containment building.

away-from-reactor (AFR) storage facilities
A wet or dry storage facility which is not co-located with the reactor. The fuel has to be transferred or transported to the storage facility. There are two classifications of AFR storage facilities: Reactor Site (RS) and Off Site (OS):

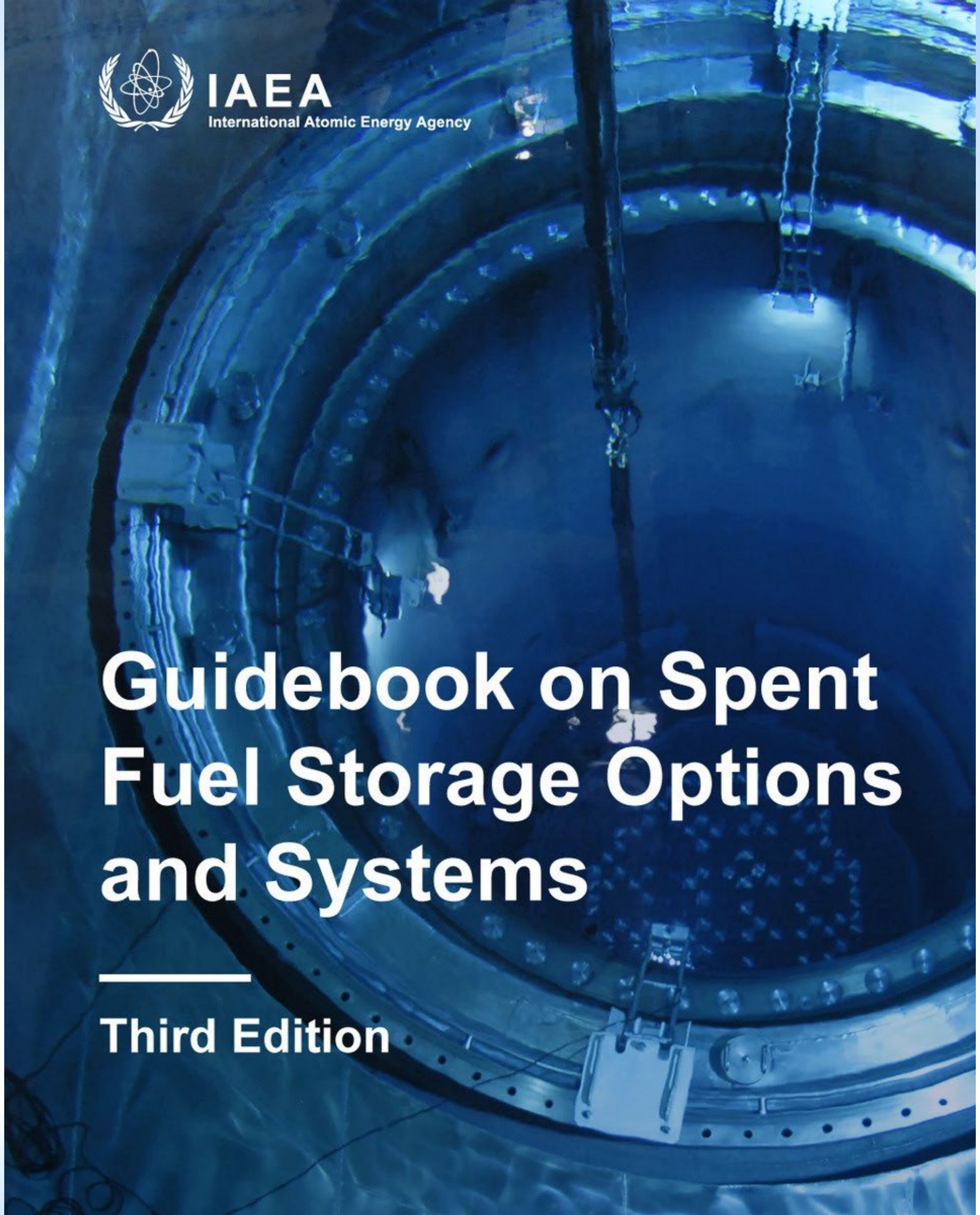
- Reactor Site (RS), is a storage facility located within the reactor site boundary. Spent fuel is transferred from one facility to the other. A further distinction can be made for an AFR(RS) in terms of those that are stand alone and can still support operations if the reactor is decommissioned, and those which are reliant on reactor services;
- Off Site (OS), is a storage facility located outside the reactor site boundary. In this case, spent fuel is transported on public roads.

basket
A moveable feature holding a number of spent fuel assemblies.

burnup
A measure of reactor fuel consumption equal to the amount of energy released per unit mass of nuclear fuel in the reactor (for power reactor fuel). Typical units for the latter are megawatt-days per tonne of uranium (MWd/t) or gigawatt-days per tonne (GWd/t).

INTERACTIVE
ON-LINE

Guidebook on Spent Fuel Storage Options and Systems



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CRPs on Spent Fuel Behaviour

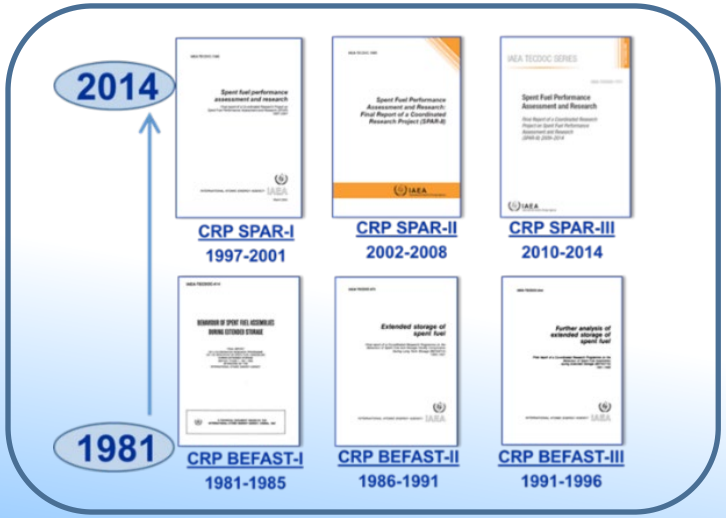
(+40y Operational Experiences and Research Worldwide)

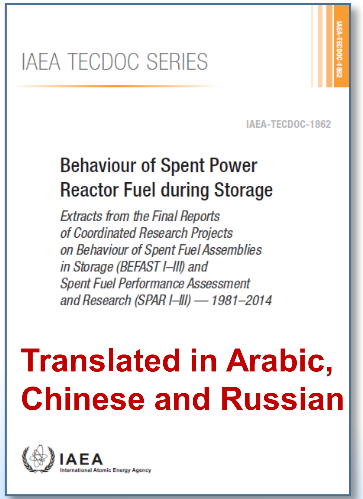
Main Objective

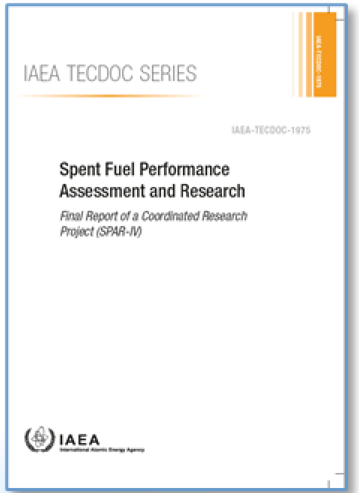
- To sustain and improve the IAEA's Member States **technical knowledge base on the long-term behaviour of power reactor spent fuel** through sharing and disseminating information, reporting topical research carried-out in participating Member States, and by documenting ongoing spent fuel performance

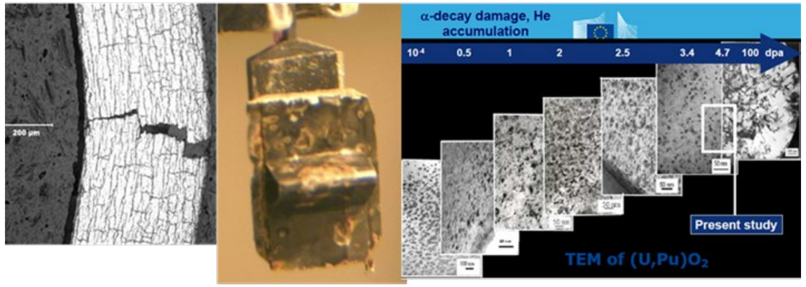
- **Series of Coordinated Research Projects** BEFAST and SPAR (1981-2020)
  - Covering all power reactor fuels: MAGNOX, RBMK, WWER, AGR, BWR, PWR, HWR, PHWR
  - Spent Fuel performance in Wet and Dry storage

BEFAST & SPAR 40+ YEARS of R&D





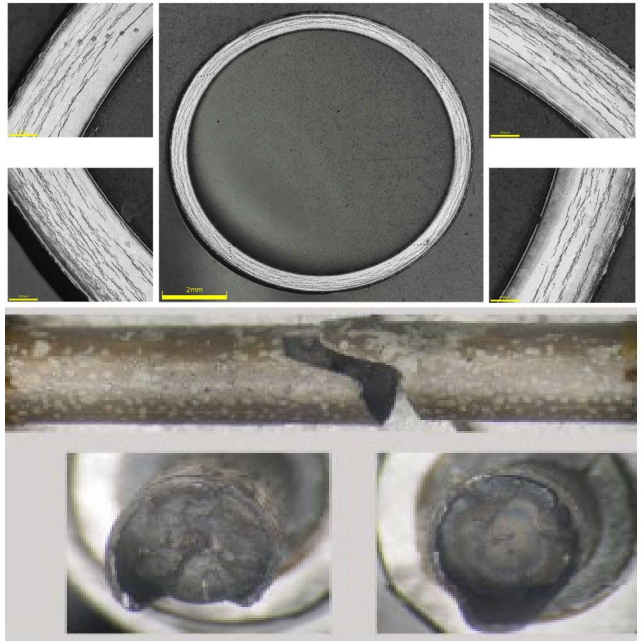




Spent Fuel Research and Assessment, SFERA (2021-2025)

Scope limited to fuel: Fuel material, Cladding, Fuel assembly structural components

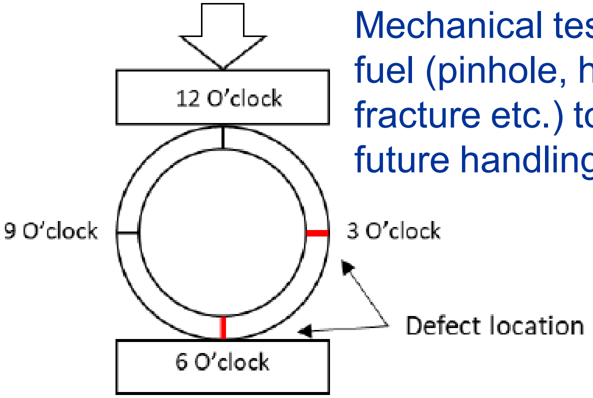
CRPs on Spent Fuel Behaviour



PNNL (top) / ORNL (bottom)

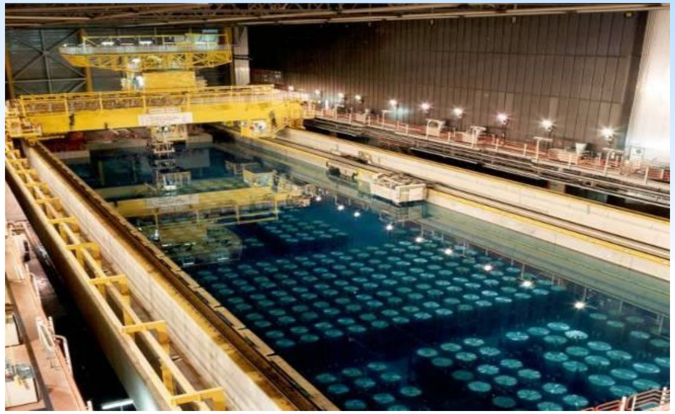
Examination & testing of the sibling pins from the High Burnup Demonstration project to establish fuel assembly condition at loading.

PNNL (defuelled) and ORNL (fuelled) to enable performance margins to be determined.



Enresa

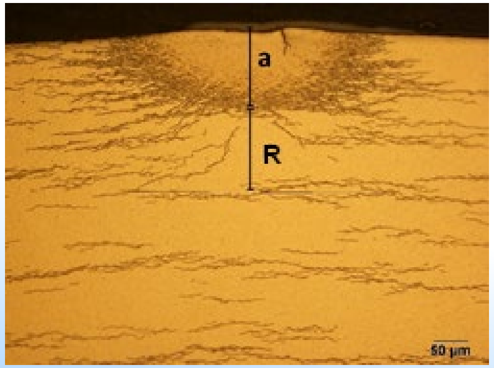
Mechanical testing on defect fuel (pinhole, hairline fracture etc.) to support future handling operations



National Nuclear Laboratory / Sellafield Limited

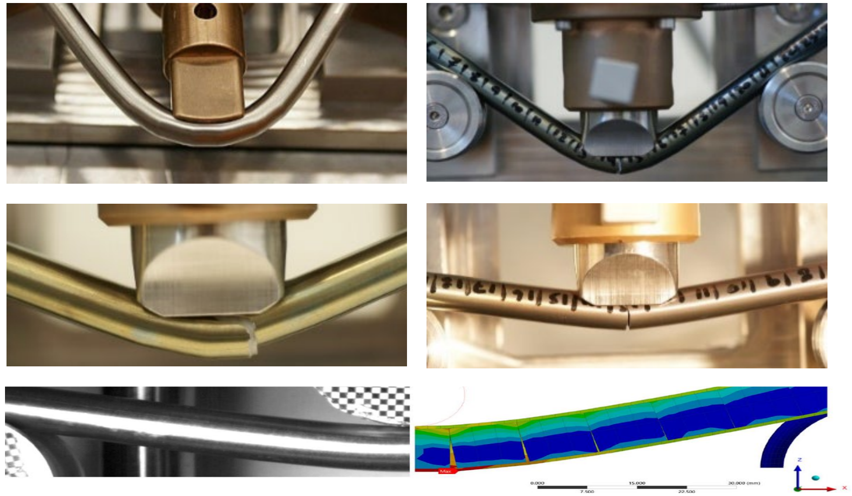
Research on various aspects to support long term wet storage of spent AGR fuel

Determination of the effect of blisters on hydride behaviour during dry storage



CNEA

Spent fuel rod mechanical testing, with data used to refine finite element modelling of rod behaviour to predict mechanical behaviour of fuel assemblies against bending loads.

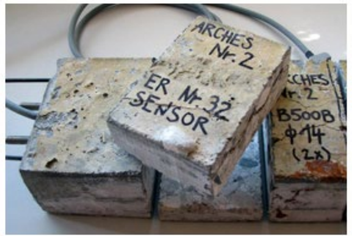


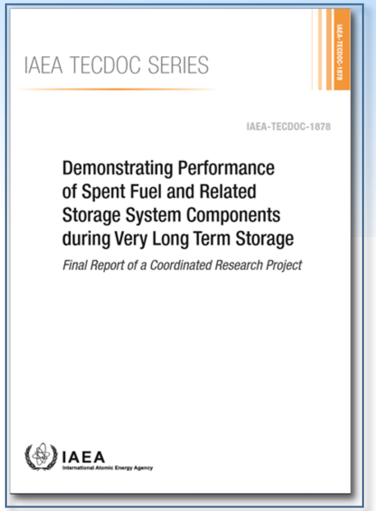
JRC Karlsruhe / Nagra

CRPs on SNF Dry Storage Systems Performance

- **Demonstrating Performance of Spent Fuel and Related Storage System Components During Very Long Term Storage** (DEMO) CRP T13014 (**Closed**, 2012-2016)

  Linked to Extended Storage Collaboration Programme (ESCP) International Sub-committee of EPRI



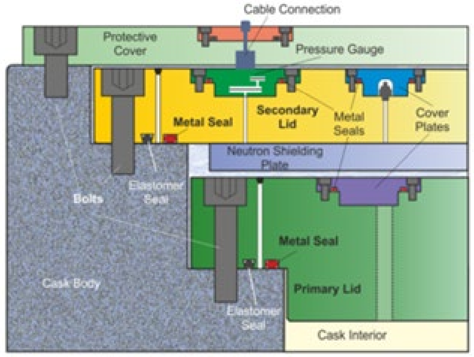

IAEA TECDOC SERIES

IAEA-TECDOC-1878

Demonstrating Performance of Spent Fuel and Related Storage System Components during Very Long Term Storage

Final Report of a Coordinated Research Project

IAEA



- **Ageing Management Programmes for Dry Storage Systems** (AMP) CRP T21028 (**Closed**, 2016-2020) *(Final Report in Drafting)*

  <u>CRP Overall Objective:</u> To develop the technical basis and methodology to enable guidance to be provided to Member States on how to generate an ageing management programme for spent fuel dry storage systems


IAEA TECDOC SERIES

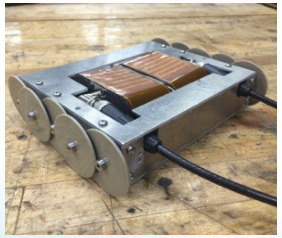
IAEA-TECDOC-1878

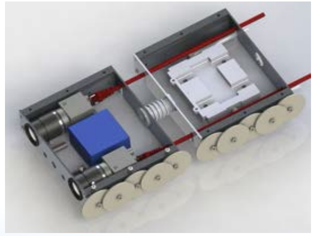
Ageing Management Programmes for Spent Fuel Dry Storage Systems

Final Report of a Coordinated Research Project

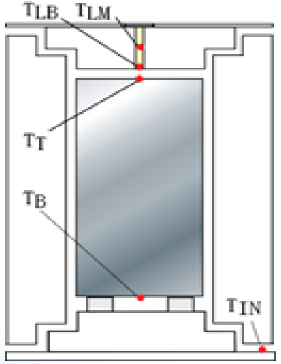
IAEA

DCSS Visual Inspection – Lid Weld *Courtesy of EPRI*





Overview about development of inspection technologies



Thermal monitoring to ensure leak tightness

Courtesy of CRIEPI

CRPs on SF Storage Systems Behaviour

Performance Assessment of Storage Systems for Extended Durations **(PASSED)**

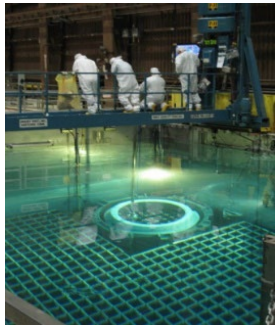
T13019 (2022-2026)

Main Objective:

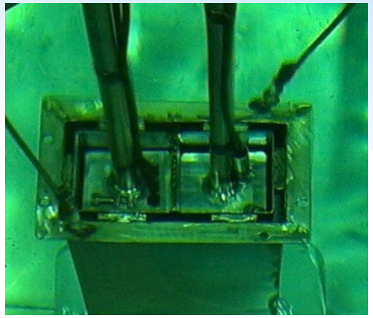
- To sustain and improve IAEA Member States' technical knowledge base on the **long term behaviour of spent fuel storage systems, inspections possibilities and monitoring technologies**, through the sharing and disseminating of technical information, the reporting on topical researches carried-out and the documentation of on-going storage systems' performance

Covers wet & dry spent fuel storage systems

– operational experiences storage system inspections
– new/novel techniques for monitoring
– predictions of spent fuel storage system behaviour over long periods
– documenting the technical basis for spent fuel storage system performance assessment
– predictions of spent fuel storage system behaviour



Coupon samples



In situ measurements

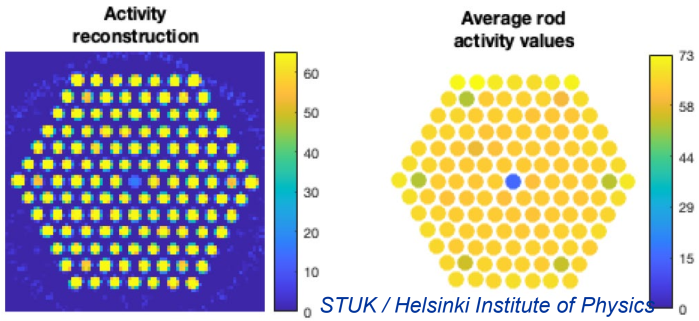
Pool panel analysis (picture courtesy EPRI)

Analysis after D&D

Enlargement of storage facilities. Courtesy PAKS

CRP on Spent Fuel Characterization, CRP T13018 (2020-2024)

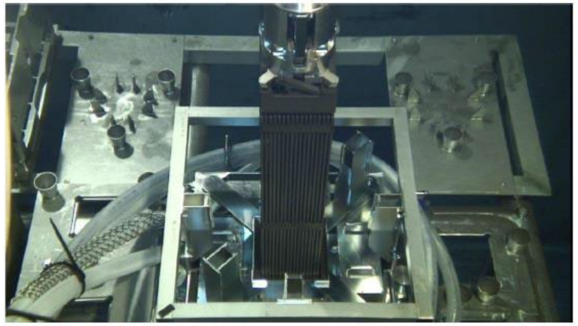
Covering a wide range of power reactor fuels: BWR, PWR, RBMK, WWER, CANDU and AGR fuels



STUK / Helsinki Institute of Physics

eurad
European Joint Programme on Radioactive Waste Management

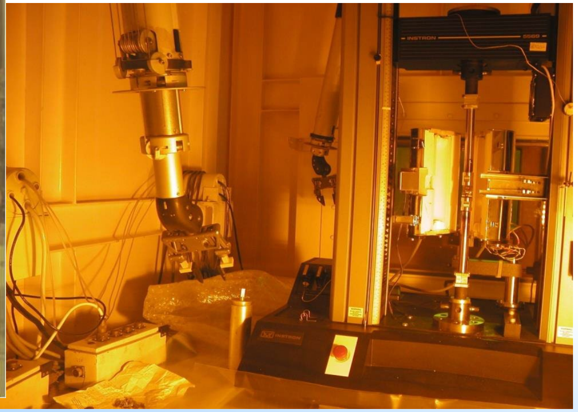
Linked to WP8


SKB / LANL

Development and testing of techniques to characterize spent fuel using **non-destructive techniques**.

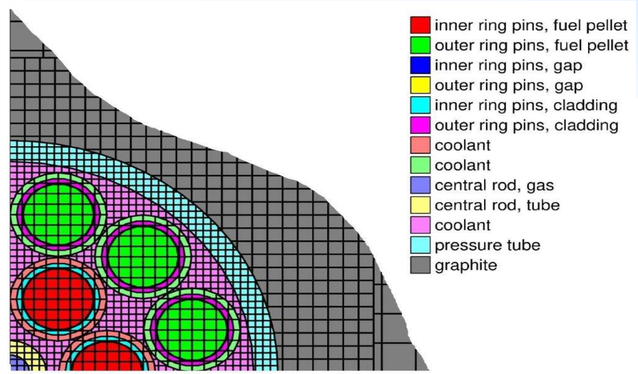
Looking for ways to characterize large populations of SF for next fuel cycle stages (e.g., disposal)


NNL

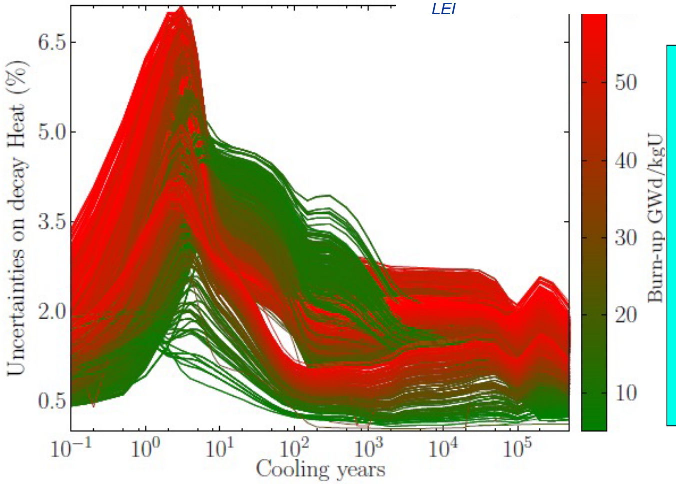

RATEN ICN

Destructive testing of spent fuels to enable full characterization and generate data points for future use.

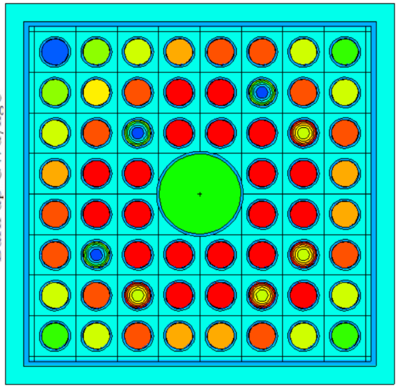
Also enables training of young staff in methods



LEI



PSI


ININ

Development, refinement and validation of **modelling techniques** for RBMK and LWR fuels. Includes assessment of biases and uncertainty for important parameters, such as **decay heat**

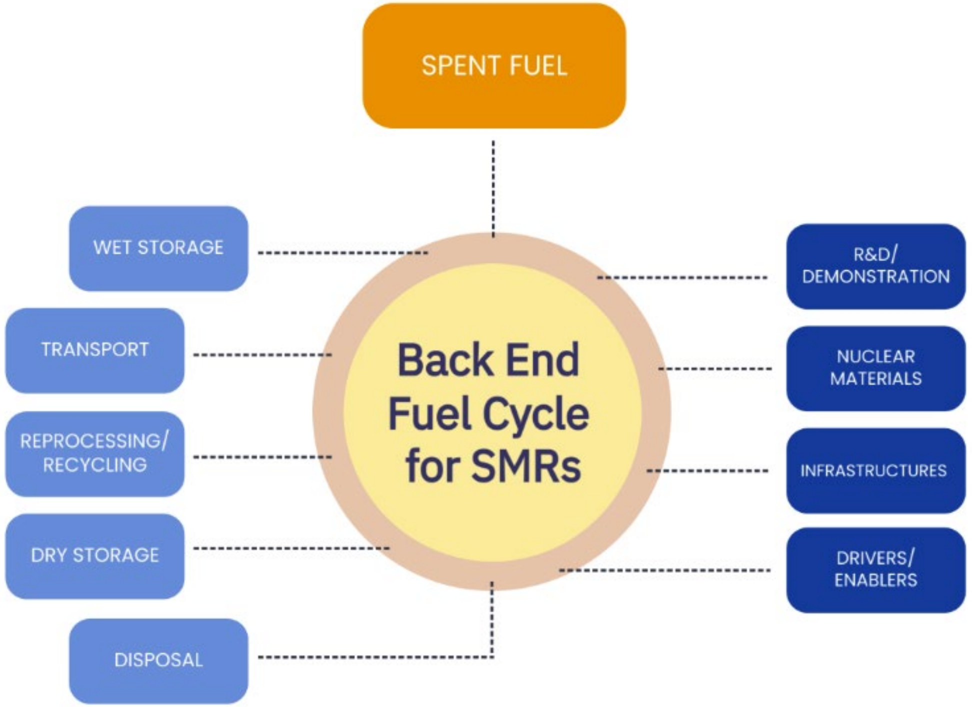
CRP on Challenges, Gaps and Opportunities for Managing Spent Fuel from Small Modular Reactors (T13021) (2023-2027)

Objectives

- To identify viable nuclear fuel cycle options for the different SMR technologies
- To **establish specific roadmaps** of activities for the backend of the fuel cycle per SMR technology, identifying what can be derived from existing practices, optimized and adapted, or fully developed considering the lack of data and gaps within existing knowledge
- To identify generic key parameters/criteria to support countries designing their backend programmes incorporating their specific context

Open for Proposals in January 2023

NEW



Challenges, Gaps and Opportunities for Managing Spent Fuel from Small Modular Reactors | IAEA

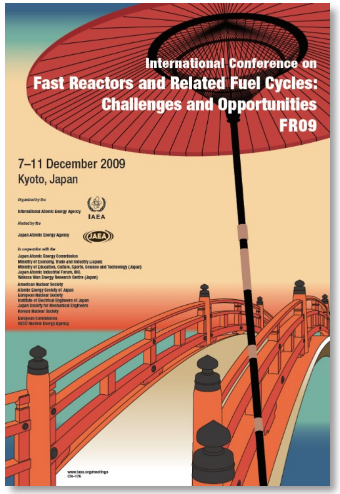
Outline

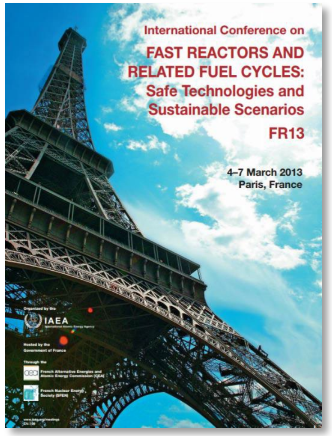
- Overview of Spent Fuel Management and Current Challenges

- **IAEA Ongoing Activities:**
  - Recent Meetings and Ongoing Publications
  - Coordinated Research Projects (CRPs)
  - **International Conferences**
  - **Outreach and Dissemination Materials**

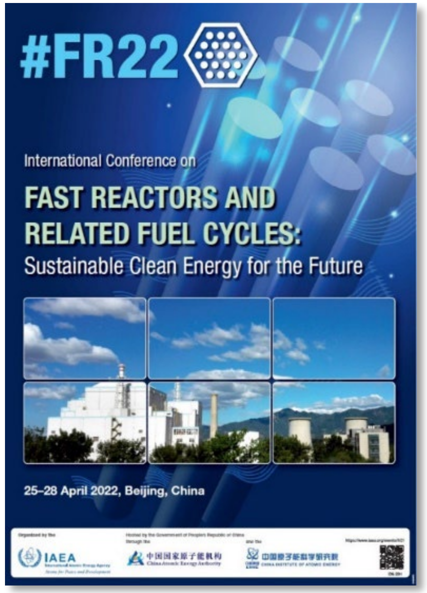
IAEA International Conference

Fast Reactors and Related Fuel Cycles (FR22)





FR22
Vienna
19-22 April 2022



FR22 Topics

- Track 1. Innovative fast reactor designs
- Track 2. Fast reactor safety
- **Track 3. Fuels, fuel cycles and waste management**
- Track 4. Fast reactor materials (coolants, structures) and components
- Track 5. Test facilities and experiments
- Track 6. Modelling, simulations and digitalization
- **Track 7. Sustainability: Economics, environment and proliferation**
- Track 8. Commissioning, Operation and Decommissioning
- Track 9. Education, professional development and knowledge management

680 participants, 365 contributors, 220 orals, 100 posters
51 countries and 3 International Organizations
About 100 people in-person, 45 participating from 3 remote conference halls in Russia and 15 from China, about 500 participants connected on-line

International Conference on Spent Fuel Management

Held every 4y since 1998

Upcoming Conference

SFM24

10–14 June 2024, IAEA Headquarters, Vienna

Outline

- Overview of Spent Fuel Management and Current Challenges
- **IAEA Ongoing Activities:**
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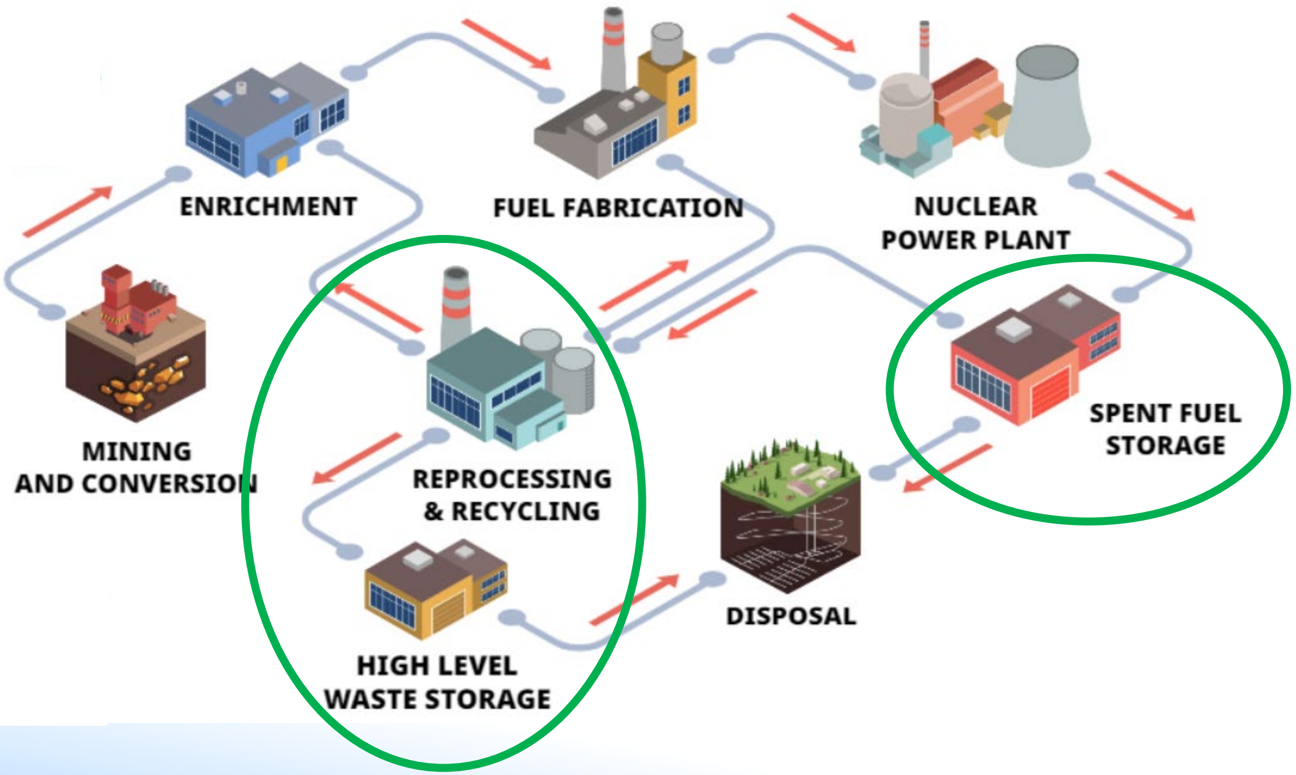
  - International Conferences
  - **Outreach and Dissemination Materials**

Development of e-Learning Material on Spent Fuel Management

Scope*



Including SNF and HLW Transportation

Who is it for?

- Professionals in the nuclear field interested in Spent Fuel Management
- Decision Makers
- Regulators
- Young Professionals
- Nuclear Engineering and
- Related Degree and Master Students
- Other Interested Stakeholders

Main Objective

- To support capacity building in Member States (MSs)
- To serve as a tool to support interested MSs in their activities to improve safe, secure and economical operations relating to the nuclear fuel cycle
- To provide a high-level guidance in taking a systematic approach, from the front to the backend of the nuclear fuel cycle

IAEA E-learning on Spent Fuel Management

The course comprises of 7 Modules with 17 Lectures in total

Each Lecture lasts about 30 minutes
+
Self Assessment Quiz (5 Q&A)

IAEA Certificate of Completion


IAEA

CERTIFICATE OF COMPLETION

This is to certify that

Amparo GONZALEZ ESPARTERO

has completed an on-line e-learning

Course on Spent Fuel Storage

on the IAEA's Learning Management System

Language: English

Certificate ID: OIfn9FcYef

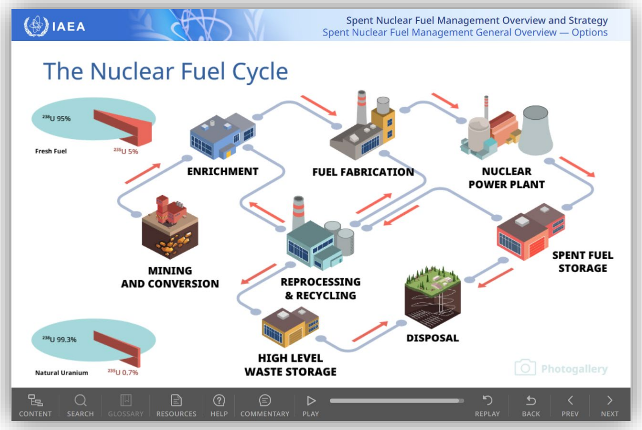
Issue date: 20 February 2020

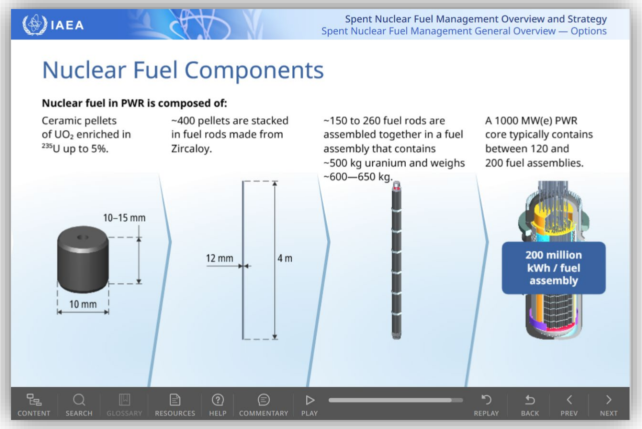
This e-learning is based on IAEA publications and training materials. Please note that the IAEA is not an accredited educational organization and the user's identify was neither verified throughout the learning process nor the assessment. The certificate ID is unique and is registered in the IAEA's Cyber Learning Platform.

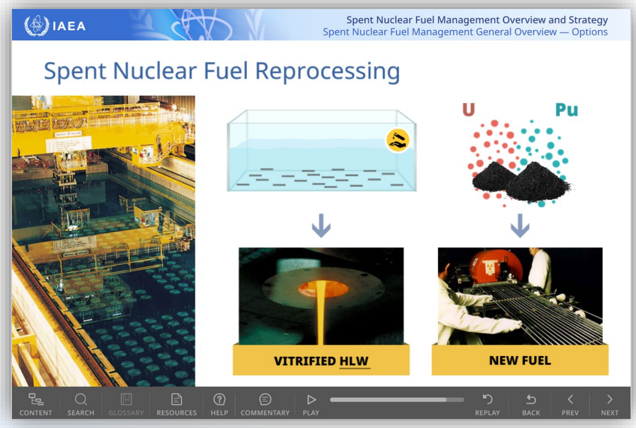
- M1: Overview and SFM Strategy
  - Lecture 1.1: General Overview. Spent Fuel Management Options
  - Lecture 1.2: Factors that could influence the choice of SFM strategy
- M2: Fundamental Principles of Spent Fuel Management
  - Lecture 2.1: Fundamental Principles of SNF Management
- M3: Spent Fuel Characteristics
  - Lecture 3.1: Spent Fuel Characteristics
  - Lecture 3.2: Spent Fuel Characterization
  - Lecture 3.3: Spent Fuel Behaviour in Wet/Dry Conditions
- M4: Spent Fuel Transportation
  - Lecture 4.1: Spent Fuel Transportation
- M5: Spent Fuel Storage
  - Lecture 5.1: Spent Fuel Storage Strategy
  - Lecture 5.2: Spent Fuel Storage Facility Design and Operation
  - Lecture 5.3: Ageing Management of Spent Fuel Storage Systems
- M6: Spent Fuel Reprocessing for Recycling
  - Lecture 6.1: Spent Fuel Reprocessing for Recycling
  - Lecture 6.2: Pu Product Management and Use
  - Lecture 6.3: RepU Product Management and Use
  - Lecture 6.4: Waste Streams from Spent Fuel Reprocessing
- M7: Advanced Fuel Cycles
  - Lecture 7.1: Overview of SNF Multirecycling using FRs
  - Lecture 7.2: Advanced Fuel Cycles for U/Pu Multirecycling
  - Lecture 7.3: Management of Minor Actinides

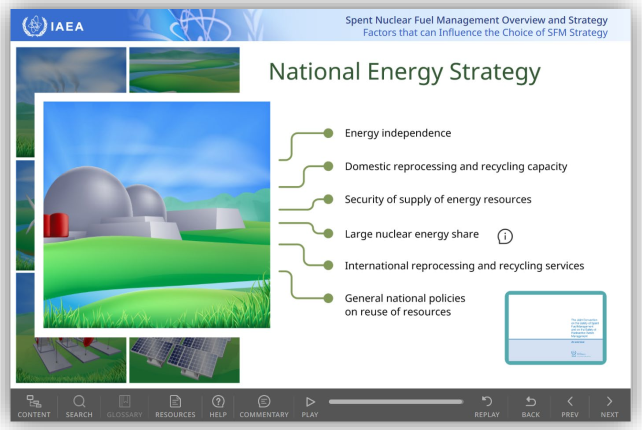
Module 1: Overview of Spent Fuel Management

- **Lecture 1.1: General Overview of Spent Fuel Management Options**
- **Lecture 1.2: Factors that can Influence the Choice of a SFM Strategy**



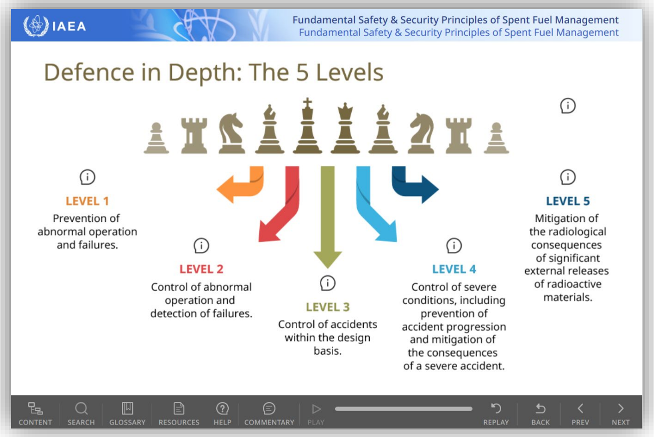




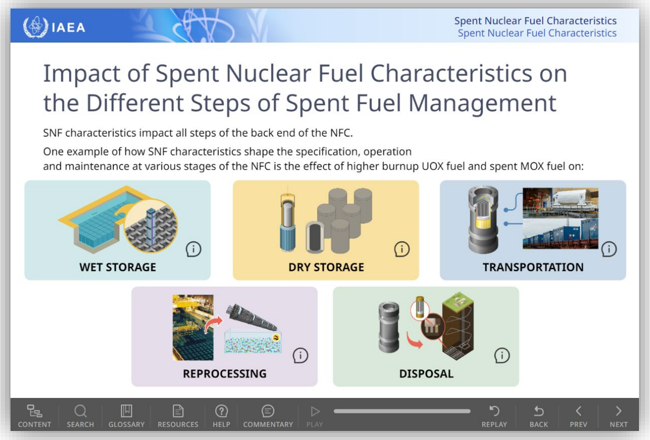


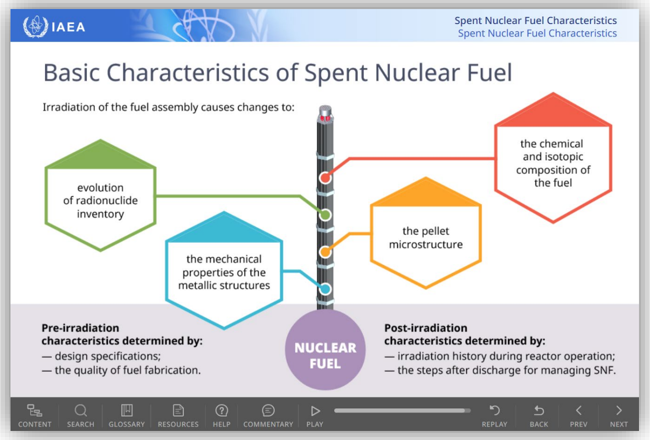
Cross-Cutting Modules

Module 2: Fundamentals Safety and Security on SFM

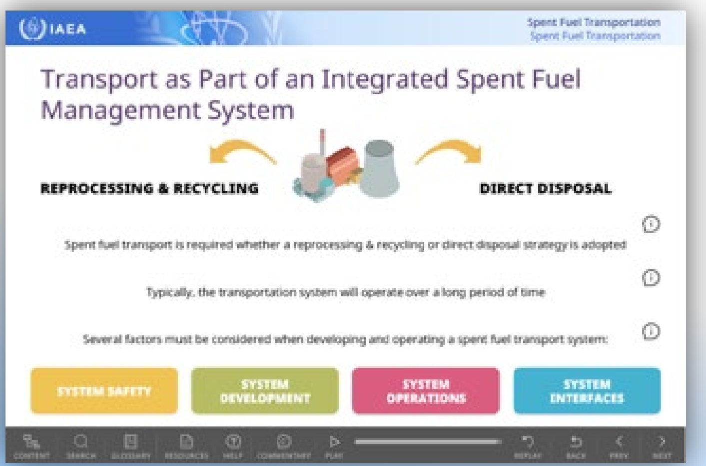


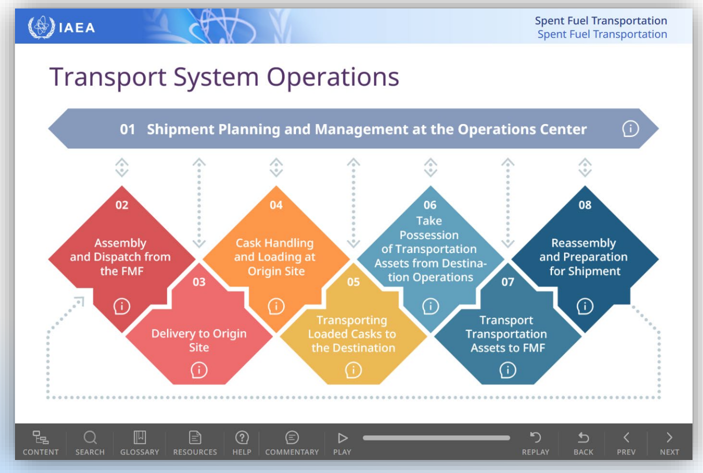
Module 3: SNF Characteristics





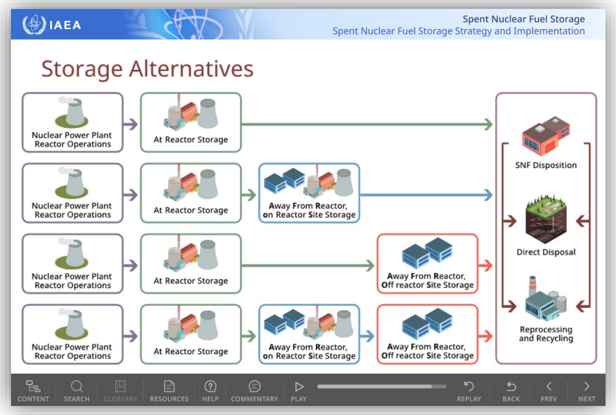
Module 4: SNF Transportation

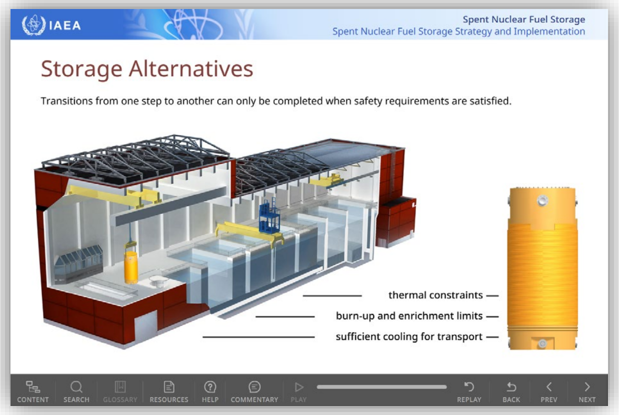




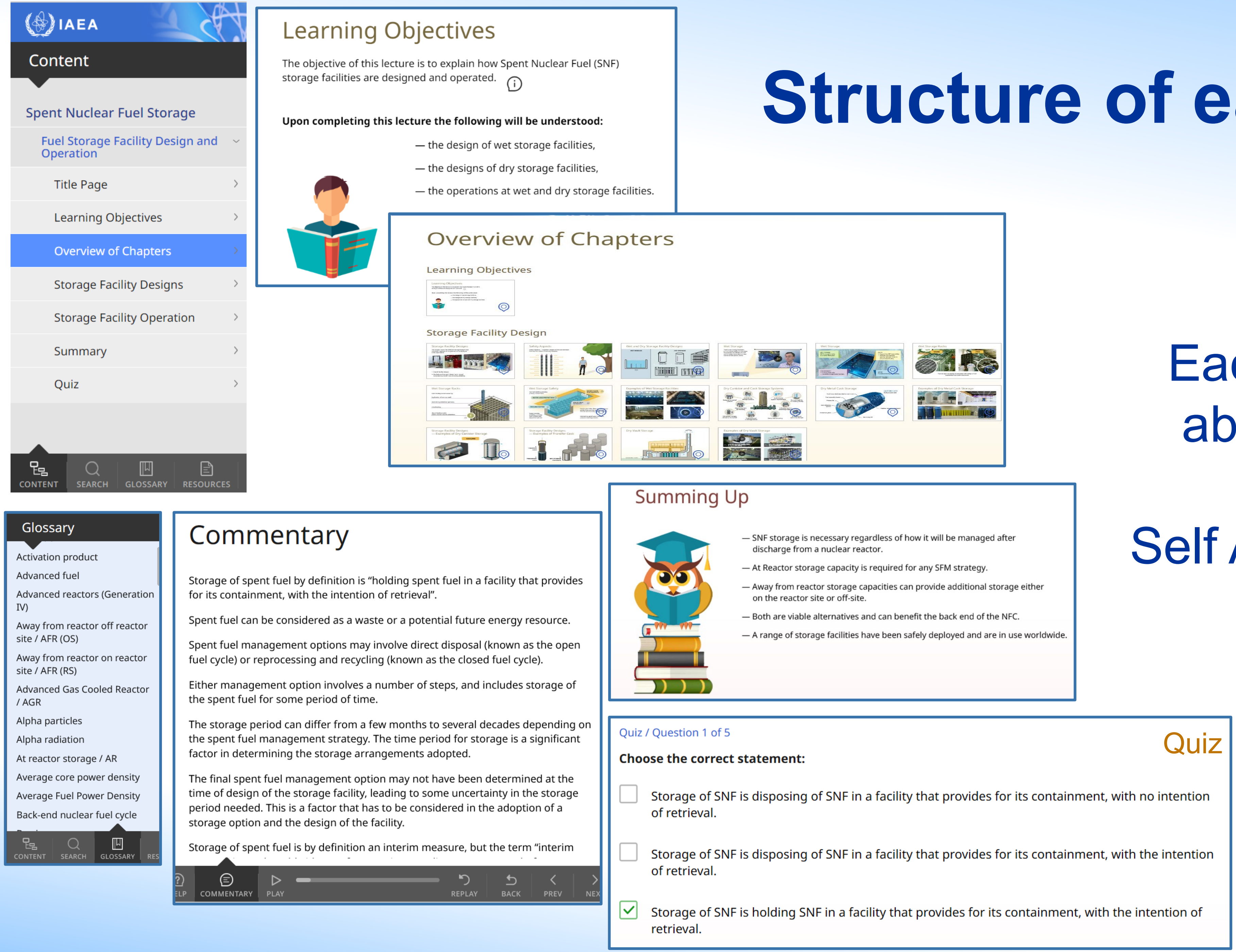
Module 5: Spent Fuel Storage

- Lecture 5.1: SNF Storage Strategy and Implementation
- Lecture 5.2: SNF Storage Facility Design and Operation





Structure of each Lecture



Each Lecture lasts about 30 minutes

+

Self Assessment Quiz (5 Q&A)

Module 1
Overview and Spent Fuel Management Strategy

Module 2
Fundamental Principles of Spent Fuel Management

Module 3
Spent Fuel Characteristics

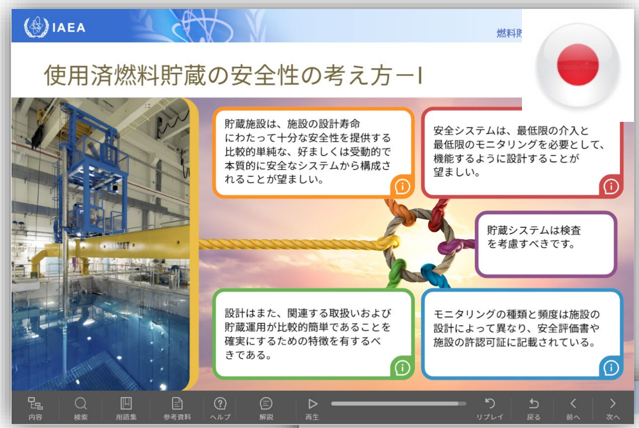
Module 4
Spent Fuel Transportation

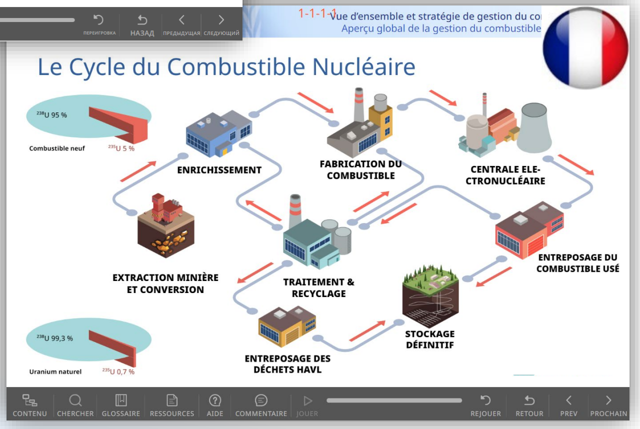
Module 5
Spent Fuel Storage

IAEA Certificate of Completion

"IAEA e-Course on Spent Fuel Management"

The course is available in additional languages

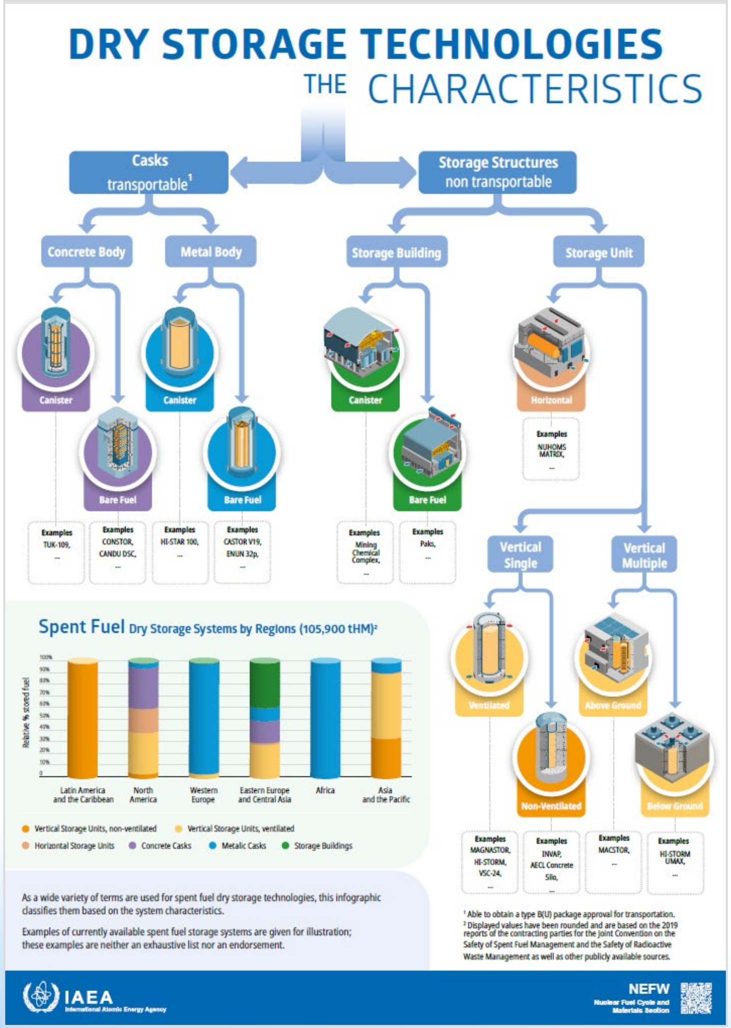


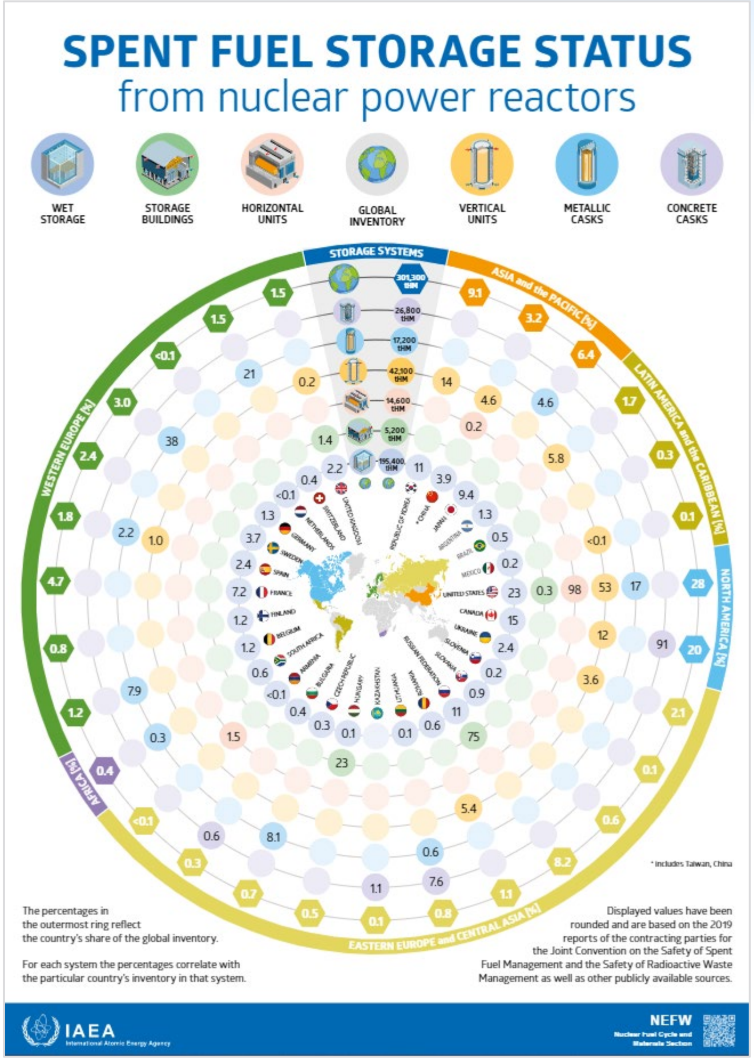


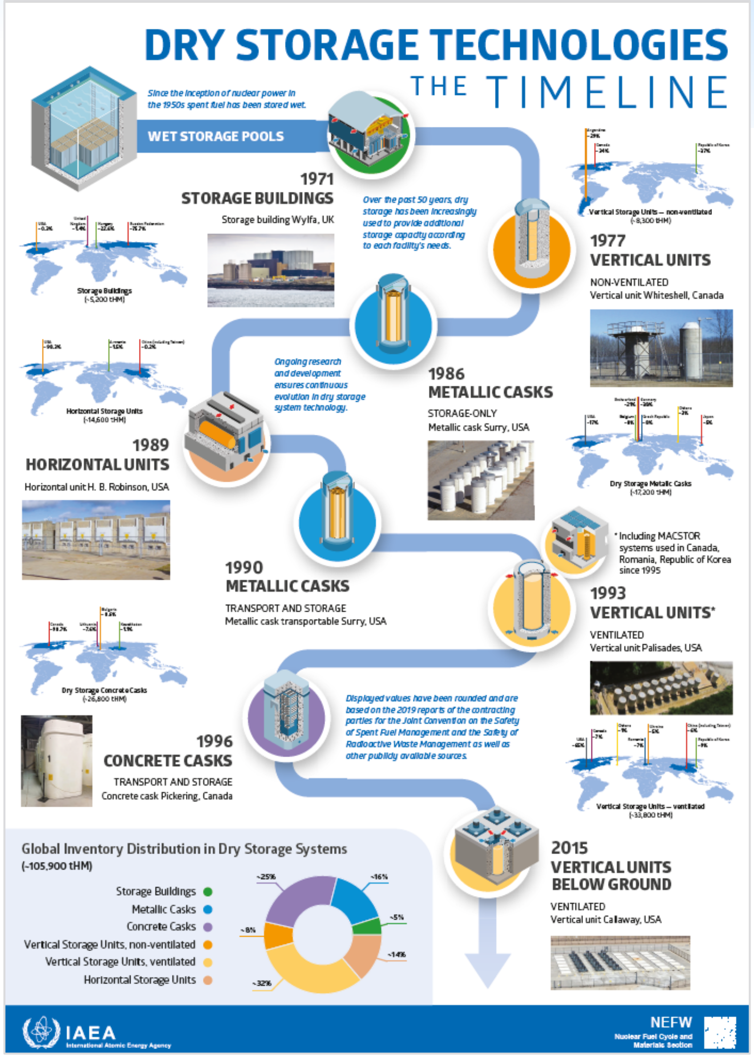
- 1200+ users accessed at least one module
- 300+ certificates issued

Coming soon

Infographics completed series



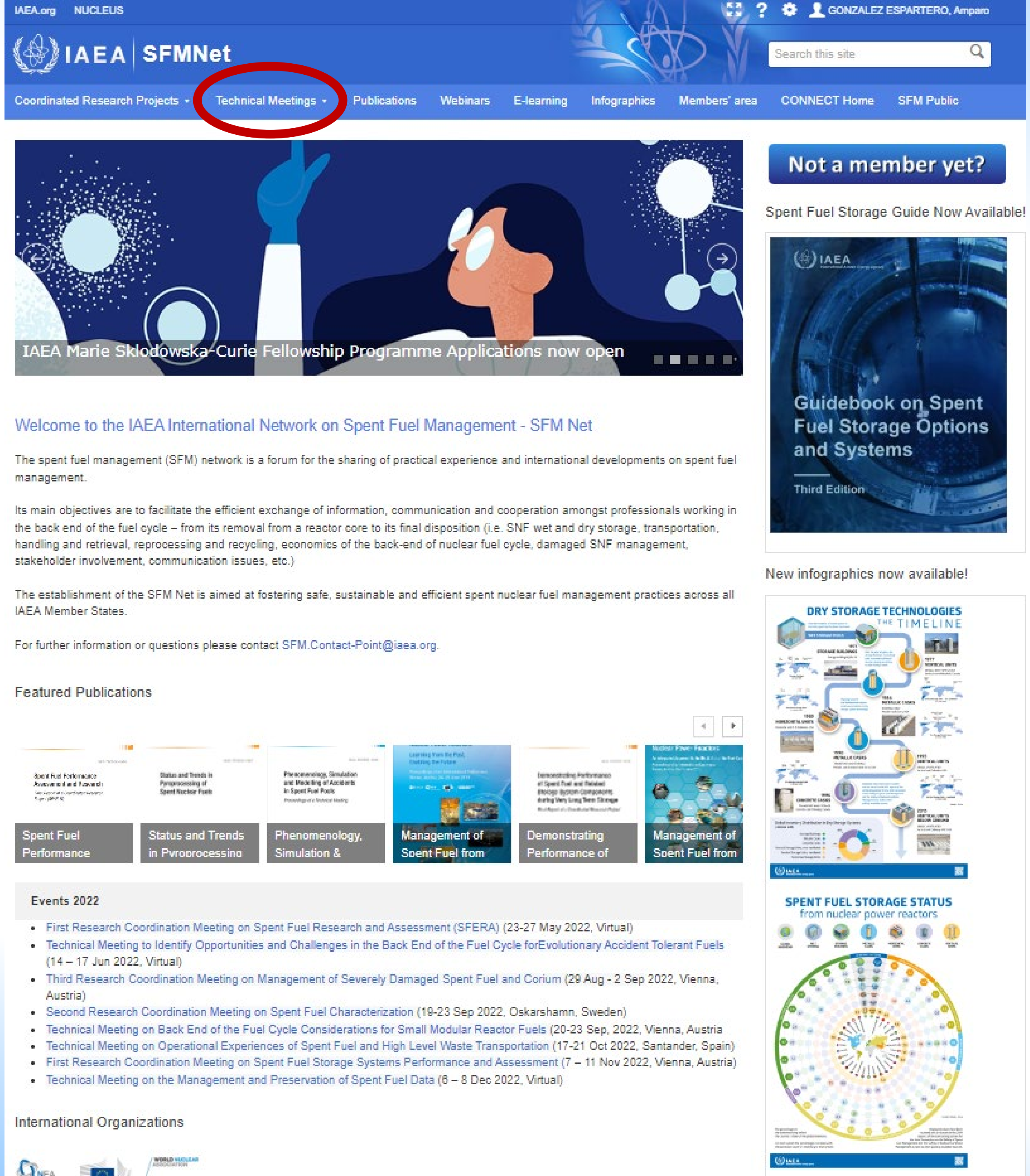




Technical Meetings/Workshops Scheduled in 2024

- Workshops
  - Chemistry of Fuel Cycles for Molten Salt Reactor Technologies, **2-6 October 2023** (In collaboration with OECD/NEA)
  - Challenges in Managing Spent Accident Tolerant Fuels **(2024)**

- Technical Meetings
  - Management of Non-Standard & Exotic Legacy Spent Fuels **(tbd)**
  - Back End of Fuel cycle for HTGRs **(tbd)**



Spent Fuel Management Network

IAEA

Interactive Guide Guidebook on Spent Fuel Storage Options and Systems

E-Learning Course on Spent Fuel Management

Webinars on Spent Fuel Management

Technical Meetings Contents

https://nucleus.iaea.org/sites/connect/SFMpublic/Pages/default.aspx

SFM.Contact-point@iaea.org

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

"Learning never exhausts the mind"

Leonardo da Vinci

IAEA Spent Fuel Management Team

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