NEA
NUCLEAR ENERGY AGENCY

NEA nuclear science and education initiatives to support the future of the nuclear energy

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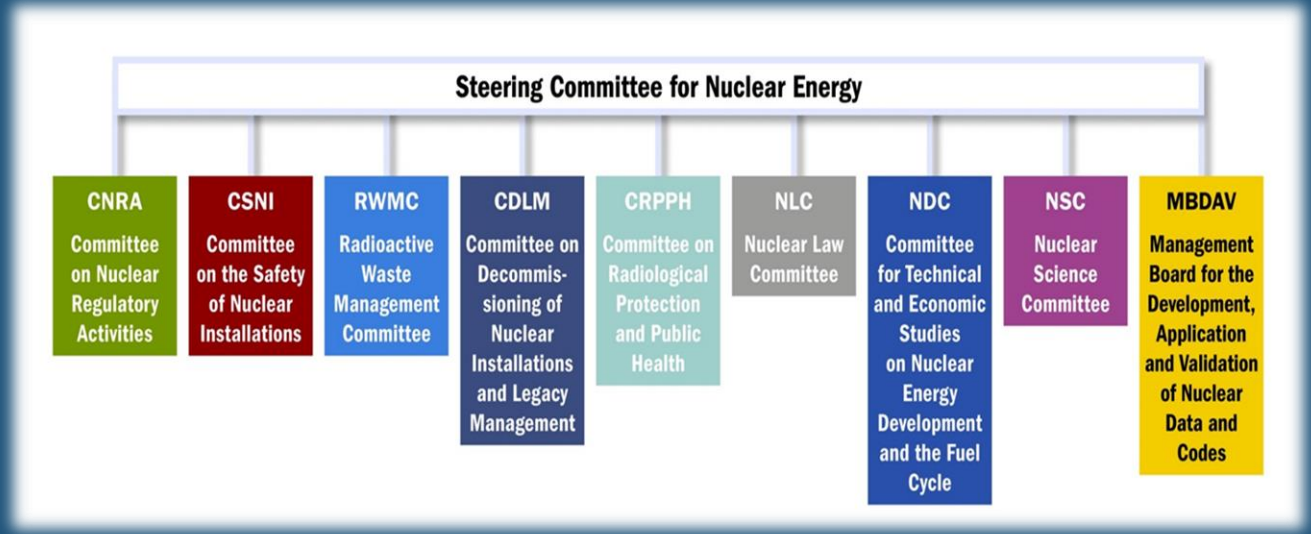
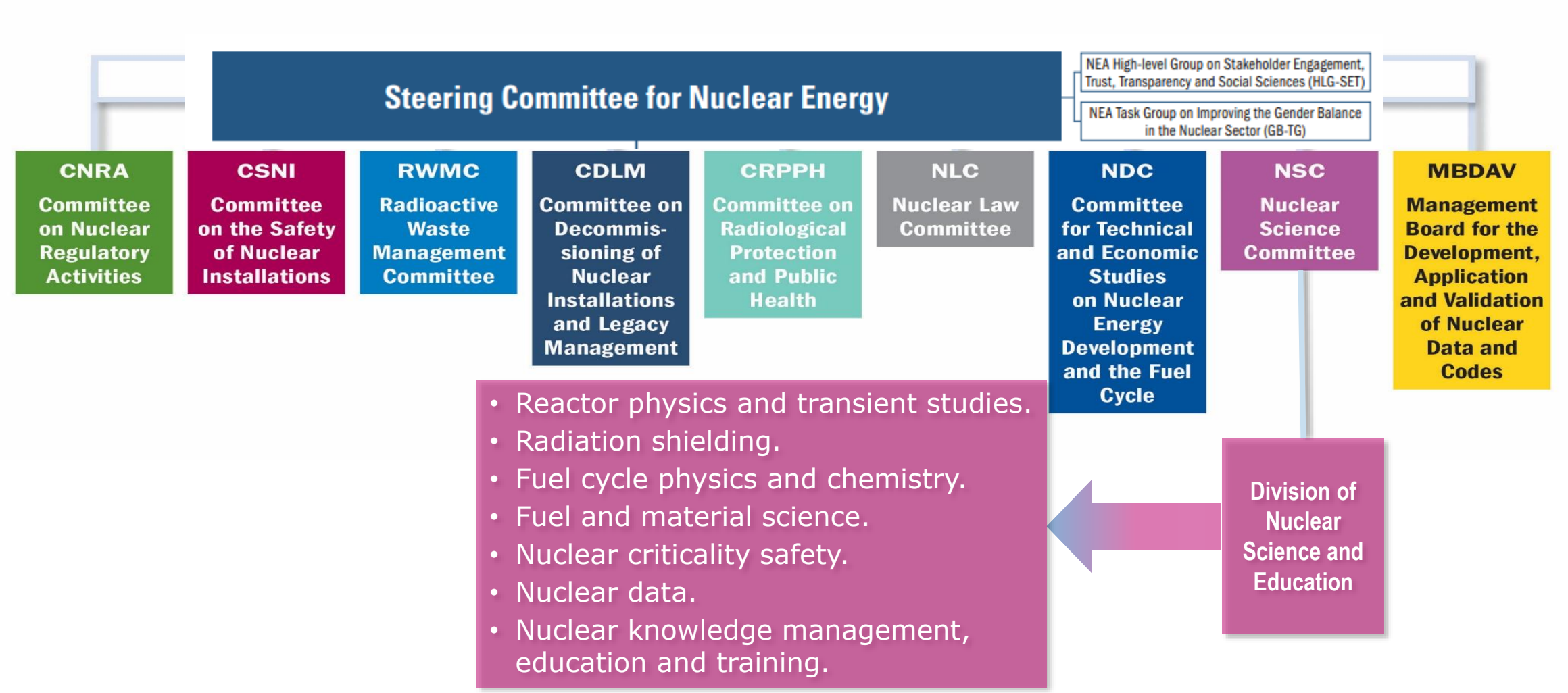
The NEA: 34 Countries Seeking Excellence in Nuclear Safety, Technology, and Policy

- 34 member countries and strategic partners
- The NEA is a framework for technical and policy cooperation in nuclear safety, stakeholder engagement, science, current and new and technology, economics, nuclear law, nuclear codes and data, waste management, decommissioning, legacy management, and radiation protection
- 8 standing committees and over 80 working parties and expert groups
- International joint projects



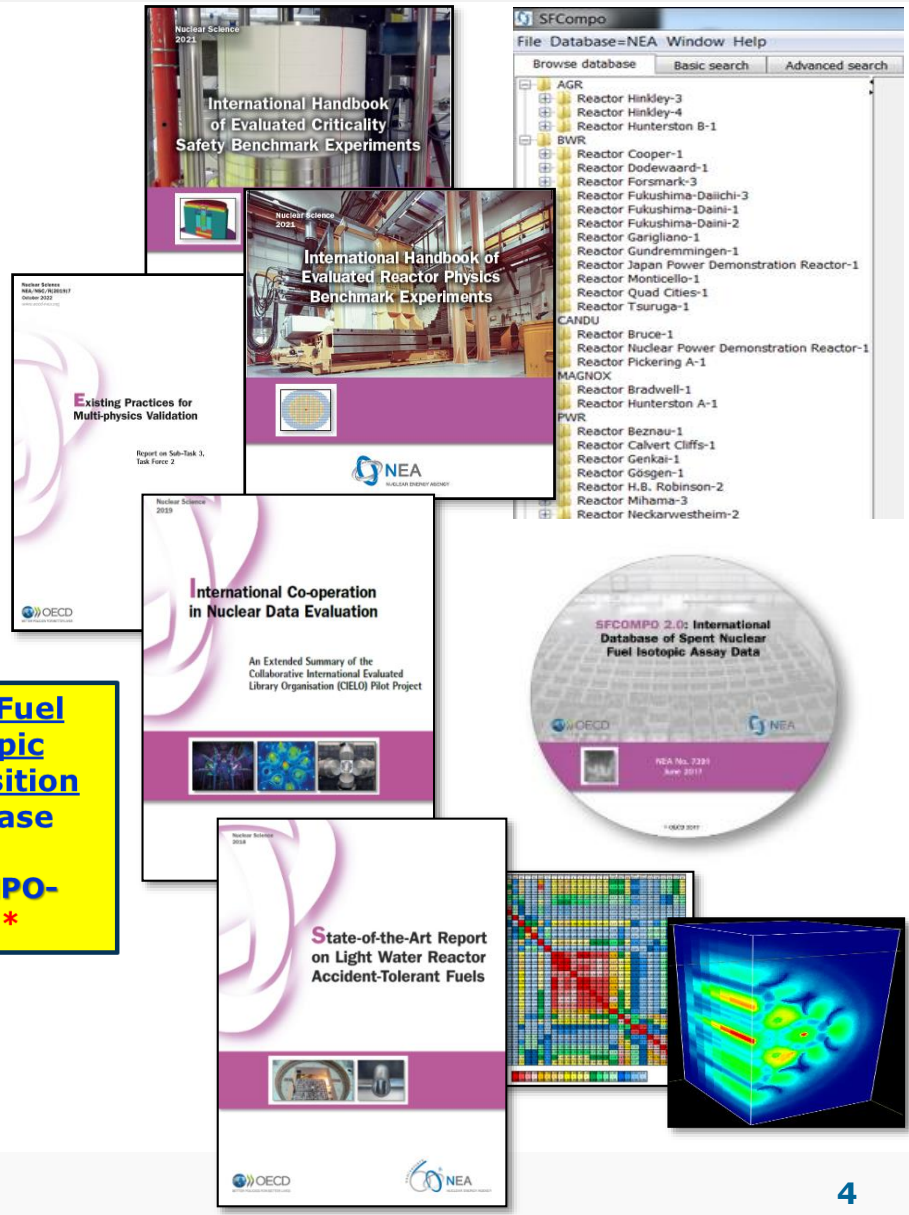
NEA countries operate about 80% of the world's installed nuclear capacity

NSC areas of work



NSC products

- State-of-the-art reports, reports on benchmark studies.
- Handbooks and collections of integral experiments.
- Relational databases.
- Graphical User Interfaces (GUIs).
- NEA software tools enhancing verification and validation (V&V) of modelling and simulations (M&S).



Collections of integral experiments

International Fuel Performance Experiments database	New IE database on Thermal Hydraulics Systems	International Radiation Shielding Experiments database	International Reactor Physics Experiments database	International Criticality Safety Benchmark Experiments database	Spent Fuel Isotopic Composition Database
IFPE*	**TIETHYS**	**SINBAD****	**IDAT**	**DICE**	**SFCOMPO-2.0****

Now with DATIF

Developed jointly by IAEA and NEA; ** Developed in co-operation with ORNL/RSICC, USA

Reactor physics, transient studies, radiation shielding

Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems (WPRS)

- International Reactor Physics Experiments
- Physics of Reactor Systems
- Reactor Fuel Performance
- Reactor Systems Multi-Physics
- Reactor Core Thermal-hydraulics/ Mechanics

Focus on innovative reactor systems and advanced modelling and simulation

Tackles technical issues underpinning nuclear power systems: optimisation of design and operation, reactor control, shielding and dosimetry, fuel performance.

Highlights

- 11 on-going benchmarks (LWR, PWR, VVER, CANDU, LFR, LMFR, MSR, HTGR).
- Release of DATIF database for fuel performance data.
- WPRS Benchmark Workshops hosted by CEA in Aix-en-Provence, France, 30 May – 3 June 2022, over 170 participants.
- 15th Workshop on Shielding aspects of Accelerators, Targets, and Irradiation Facilities (SATIF-15) hosted by Michigan State University, US, 20-23 September 2022, over 120 participants.

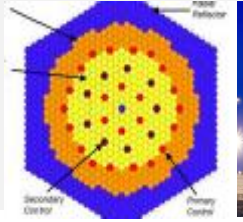
2023 events

- International School on Simulation of Nuclear Reactor Systems (SINUS), Pilot Session, May, organised jointly with NEA Data Bank, NCSU, ORNL/RSICC (USA), ENEA (Italy), EC ENEN 2 Plus project (travel grants for 20 students).
- WPRS benchmark workshops, May, hosted by ENEA, Italy.

New activities

- International School on Simulation of Nuclear Reactor Systems (SINUS) for students and young professionals.
- Task Force on the Needs for Zero Power Reactors.
- Task Force on Machine Learning (ML) and Artificial Intelligence (AI).
- Task Force on modernisation of the Shielding Integral Benchmark Archive and Database (SINBAD).

Reactor physics: benchmarking to enhance M&S



Ongoing benchmark activities	Reactor type	Neutronics	Thermal-hydraulics	Multi-physics	Fuel performance	Participants	Countries
Benchmark for Uncertainty Analysis in Best-Estimate Modelling for Design, Operation and Safety Analysis of • Light Water Reactors (LWR-UAM)	**LWR**	Focus on uncertainty quantification, wide range of LWR and SFR applications				232	22
• Sodium-cooled Fast Reactors (SFR-UAM)	**SFR**					142	19
Fluoride-salt-cooled High temperature Reactor (FHR) benchmark	**MSR**	Heterogeneities				27	5
Deterministic Time-Dependent Neutron Transport Benchmark without Spatial Homogenization (C5G7-TD)	**LWR**	High fidelity to low fidelity information				184	23
TVA Watts Bar Unit 1 Multi-Physics Benchmark	**PWR**			Plant measurements and observations		89	14
Rostov-2 VVER-1000 Multi-Physics Benchmark	**VVER**					68	15
Liquid Metal Fast Reactor Core Thermal-Hydraulics Benchmark (LMFR T/H)	**LMFR**		High fidelity simulations vs experiment			44	12
McMaster Core Thermal-Hydraulics Benchmark	**CANDU**					58	16
Multi-physics Pellet Cladding Mechanical Interaction Validation (MPCMIV) Benchmark	**PWR**			High fidelity vs low fidelity, comparison to experimental data		60	13
Lead Fast Reactor Benchmark	**LFR**	Depletion				29	11
HTGR thermal-hydraulics benchmark based on measurements at HTTF Facility, USA	**HTGR**		Simulations vs experiment			20	4

+ several completed benchmarks, distributed by Data Bank, focusing on different physical phenomena of HTGR, PBMR, LWR and other reactor types.

Reactor physics: training new generation of M&S experts

International School on Simulation of Nuclear Reactor Systems (SINUS), Pilot Session

- Topic: use of NSC benchmarks for V&V of reactor physics M&S.
- Combination of virtual training and in-person training:
  - 20h of virtual training: basic trainings on tool, technical background, 2–12 May 2023.
  - 2 day of in-person training during the annual WPRS Benchmarks Workshop,
    22-23 May 2023 in Bologna, Italy, hosted by ENEA.
- Pilot session became possible due to support of NCSU (US), ENEA (Italy), EC ENEN 2 Plus, and ORNL/RSICC (US).
- Over 60 applications, 31 selected trainees (40% women) from 18 countries.
- Next sessions are scheduled for 2024 in Italy and in 2025 in Canada.

Nuclear fuel cycle physics and chemistry

Working Party on Scientific Issues of the Advanced Fuel Cycle (WPFC)

- Reactor Coolants/ Components Technology
- Innovative Fuels Elements
- Advanced Fuel Cycle Scenarios
- Fuel Recycling and Waste Technology

Focus on advanced fuel cycles and back-end issues

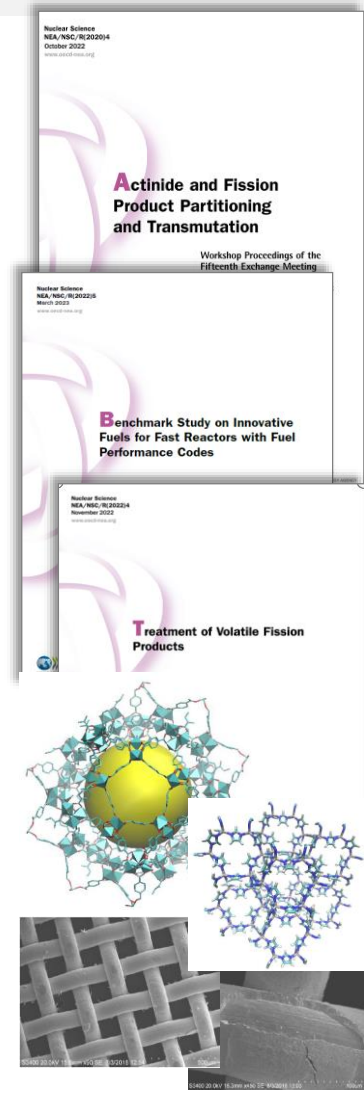
Covers several aspects of the nuclear fuel cycle from front- to back-end: fuel elements, coolant technologies, recycling and reprocessing, spent fuel and waste management, fuel cycle scenarios.

Highlights

- Focus on closed fuel cycles with hydro- and pyro-reprocessing, plutonium burning/multi-recycling, and minor actinide transmutation.
- New Task Force, originating from NI2050, has been proposed on the acceleration of fuel qualification process, planned for launch in 2024.

2023 events

- 16th Information Exchange Meeting on Actinide and Fission Product Partitioning and Transmutation (16IEMPT), October, NEA Headquarters. Dates
- NEA-IAEA Chemistry of Fuel Cycles for Molten Salt Reactor (MSR) technologies, September, IAEA Headquarters. Dates



Joint Project on Waste Integration for Small and Advanced Reactor Designs (WISARD) is being launched jointly with the Radioactive Waste Management Division

- information meeting scheduled for 19 September 2023.

Task Force on demonstration of fuel cycle closure including P&T for industrial readiness by 2050, launched in September 2020, reporting in 2024

- A High-level Report being finalised.

Fuel and material science

Working Party on Material Issues in Nuclear Fuels and Structural Materials (WPFM)

Expert Group on Fuel Materials

Expert Group on Structural Materials

WPFM established in 2021 with objectives to

- Consolidate and improve co-ordination of NSC activities in the area.
- Build closer links between M&S activities and experimental studies.
- Establish an interface between related NEA, IAEA and other activities.
- Support NEA joint projects, including FIDES-II.

WPFM is well integrated with complimentary communities of practice working on a spectrum of scales and scenarios.

Highlights

- 6th International Workshop on Structural Materials for Innovative Nuclear Systems (SMINS-6) hosted by Idaho National Laboratory (INL), US, 12-15 September 2022, over 100 participants.
- Materials Modelling and Simulation for Nuclear Fuels (MMSNF) workshop, organised by CNL at McMaster University, Hamilton, Ontario, Canada, 24-26 October 2023.

Joint Projects

Second NEA Framework for Irradiation Experiments (**FIDES-II**), launched in Q4 2022.

Thermodynamic Characterisation of Fuel Debris and Fission Products Based on Scenario Analysis of Severe Accident Progression at the Fukushima Daiichi Nuclear Power Station (**TCOFF**) Phase 2, launched in Q3 2022.

Thermodynamics of Advanced Fuels – International Database (**TAF-ID**), Phase 3, launched in Q1 2023.

QUENCH-ATF - Accident Tolerant Fuel cladding bundle testing at QUENCH facility, launched in Q1 2021.

Photo of nuclear fuel pellets and fuel rod, USDOE

https://www.oecd-nea.org/science/taf-id/
https://www.oecd-nea.org/science/tcoff/
https://www.oecd-nea.org/science/quench-atf/

Nuclear criticality safety

Working Party on Nuclear Criticality Safety (WPNCS)

- International Criticality Safety Benchmarks Evaluation
- Assay Data of Spent Nuclear Fuel Database
- Integral Experiment Covariances
- Experimental needs for criticality safety
- Uncertainties of used fuel inventory
- Effect of temperature on criticality of PWR FA

Covers criticality safety studies for static and transient configurations encountered in the nuclear fuel cycle, including fuel fabrication, transport, and storage.

Highlights

- WPNCS celebrated 25 years of contribution to the nuclear energy sector.
- Scope is extended to cover studies related to the decay heat of irradiated nuclear fuels - a key metric for the back-end handling of fuel assemblies.

New edition of the ICSBEP Handbook, November 2022

- Contains 5 121 critical, near-critical or subcritical configurations, 45 criticality alarm placement/shielding configurations, and 237 fundamental physics measurements.
- Benefits from rigorous international peer-review and quality assurance, which is seen as trustworthy by the nuclear community, including regulators.

2023 event

- International Nuclear Criticality Safety Conference (ICNC2023), dates October, co-organised with JAEA, Japan.

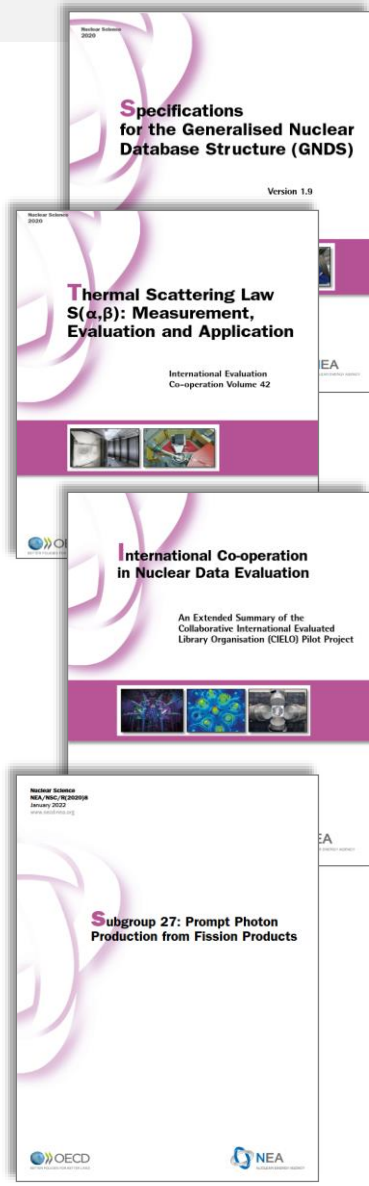
New Activity on the Spent Nuclear Fuel Decay Heat: Assessing the Confidence Level in Experimental and Computational Estimations.

Nuclear data

Working Party on International Nuclear Data Evaluation Co-operation (WPEC)

- High Priority Request List (HPRL)
- Generalised Nuclear Data Structures (GNDS)
- Automation of Experimental Reaction Database
- Advances in Thermal Scattering Law Analysis

- **WPEC brings together key experts from nuclear data programmes** to:
  - Exchange on best practices, state-of-the-art techniques and strategic needs.
  - Co-ordinate international projects on topics with strong common interest.
- **52 groups over 33 years, 4 active groups with over 50 active experts that**:
  - Deliver valuable outputs to improve Evaluated Nuclear Data Libraries.
  - Develop/maintain international standards and priority lists for experiments.
- **Knowledge preservation and Nuclear Data for innovative systems are top priorities in recent groups.**



Highlights

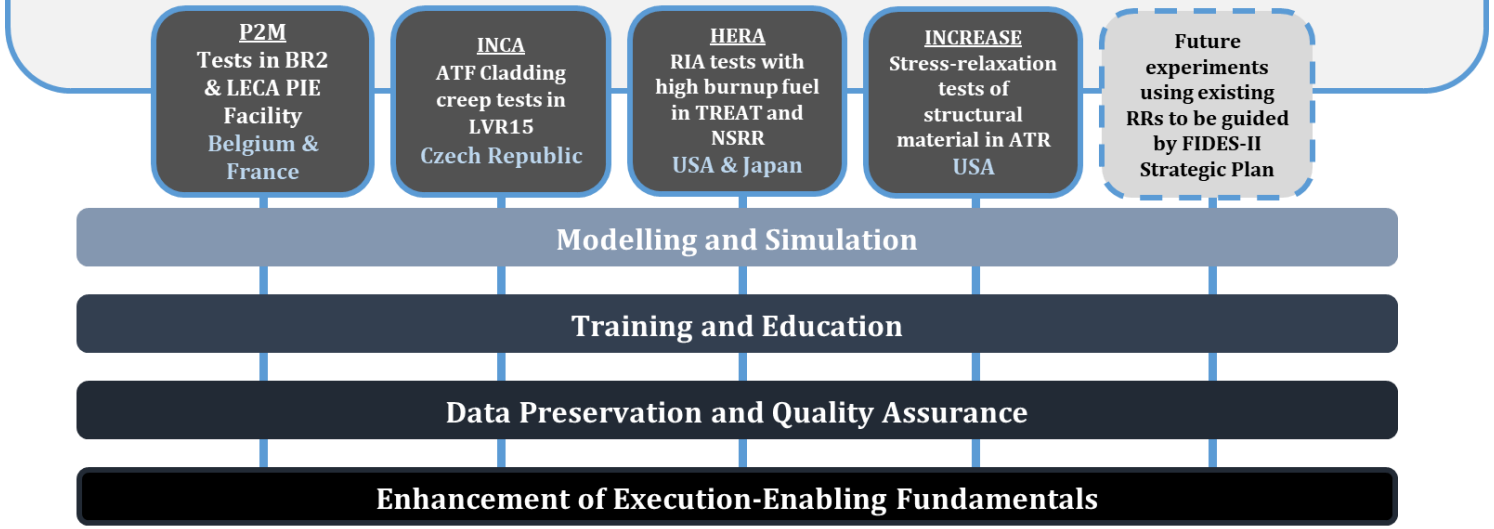
- HPRL continues to host the list of highest priority measurements following rigorous international peer-review, to guide decision takers.
- GNDS has approved a major update in the version 2.0 specifications for the international standard in nuclear data formats. New versions will have a significant increase in complexity of data.

Future developments

- Future development with Data Bank of APIs for databases of experimental data and integration into automatic workflows for nuclear data development (e.g. JEFF but also could be applied to others from the United States and Japan).
- WPEC is launching a new work area on unresolved resonance range treatment.

Second Framework for Irradiation Experiments (FIDES-II)

- NEA joint undertaking, established pursuant to Article 5 of the NEA Statute in co-ordination with the NSC and the Committee on the Safety of Nuclear Installations (CSNI)
- A stable, sustainable, reliable platform for fuel and material testing using nuclear research reactors in NEA member countries. Generates experimental results and expertise for shared costs
- FIDES-II Program of Work includes 4 Joint Experimental Programmes (JEEPs) and cross cutting pillars



Recent achievements

- New JEEP (INCREASE) focused on structural material approved in Jan. 2023.
- Task force organised to prepare additional JEEP on advanced fuel.
- 10 year Strategic Plan prepared.
- Three tests completed under HERA.
- Cr-Coated claddings loaded in the LVR-15 reactor under INCA.
- M&S exercise completed under P2M with a special issue in Journal of Nuclear Technology under preparation.
- **FIDES-II has become a center of gravity for the international community to address R&D needs related to nuclear fuels and materials.**
- **The framework model, connecting a portfolio of test reactor capabilities, offers unprecedented flexibility and scope within a single project.**

Nuclear Education, Skills and Technologies (NEST) Framework

Launched in February 2019

Objectives

- Develops skills and competences and transfer knowledge through hands-on training related to challenging nuclear projects.
- Fosters human capacity-building networks.
- Promotes the creation of new ideas and technologies.
- Allows access to infrastructure, construction projects, and decommissioning activities.

Status

- Joint project, 15 signatories from 10 countries, including all G7 countries (when UK will join); Romania will join soon.
- Projects: 6 ongoing, 2 upcoming.
- Over 50 participating organisations.
- **Over 200 Fellows in 2019-2022, 30% women.**
- NEST Alumni Network under development.
- Continuing to forge partnerships with other organisations.

NEST Fellows speak:

"The exposure to a wide-range of nuclear technologies and applications broadened my understanding of the complexity of the nuclear field".

"I come from a social science background but the training increased my horizon regarding nuclear education, which I never thought I was ever going to have throughout my life".

"This project has leaved a prominent hallmark on my future plans".

Ongoing Projects

- Hydrogen containment experiments for reactor safety (**HYMERES**).
- Small modular reactors (**SMRs**).
- Advanced remote technology and robotics for decommissioning (**ARTERD**).
- Radioactive waste management of i-graphite (**i-graphite**).
- Medical applications, nuclear technologies, radioprotection and safety (**MANTRAS**).
- Building competence, expert knowledge, applied techniques, safe decommissioning, train fellows (**BEAST**).

2022-2023 events

- BEAST Summer School, 6-9 Sept. 2022, Aachen, Germany
- ARTERD Seminar, 27 Sept. 2022, online.
- SMR Workshop @G4SR/GIF, 3 Oct. 2022, Toronto, Canada.
- BEAST @ ICOND Conference, 15-17 Nov. 2022, Aachen, Germany.
- Plenary Talk @IYNC, 30 Nov. 2022, Andreas Pautz, NEST MB Chair.
- Keynote Panel with Fellows @ENYGF, Krakow, 8-12 May 2023 with ENEN.
- SMR Summer Workshop, Idaho National Lab, 22-26 May 2023 with ENEN2plus.
- Annual Event and Award @World Nuclear Exhibition, Paris, 28-30 Nov. 2023.

Global Forum on Nuclear Education, Science, Technology and Policy

Launched in January 2021

Provides a platform for sustained co-operation amongst academic institutions, policy makers and stakeholders to address international policy challenges and develop collective actions to promoting nuclear education.

Council of Advisors (35 members from 20 academic institutions)

Working Group 1	Working Group 2	Working Group 3	Working Group 4	Working Group 5
Gender balance in nuclear technology and academic workforces	Future of Nuclear Engineering Education	Relationship between nuclear energy and society	Innovations in the nuclear sector	Nuclear Law (New)

2022-2024 events

- 3rd Annual Global Nuclear Science and Engineering Commencement, theme "Nuclear technology in service to Society", virtual, 29 June 2022.
- 1st country specific workshop "Challenges of nuclear education", 19-20 July 2022, Tokyo, Japan, co-organised with MEXT and the UOT.
- 1st Rising Star Workshop, MIT, US, 20-21 September 2023, co-organised with MIT, next workshop is scheduled for 2024, co-organized with SNU, Korea.
- 2nd country specific workshop "Encouraging greater cohesion of social sciences and STEM to push the nuclear sector forward", being scheduled for 16-17 October 2023, co-organised with SNU and KORAD, Korea.
- 1st Global Forum Symposium, being scheduled for 2024, co-organised with KAIST, Korea.

Status

- The programme of work within each Working Group is aligned with other relevant NEA activities and being implemented.
- On-going survey on future of nuclear education will help guide the programme of work.
- Continuing to expand partnership with universities around the world.

Summary: latest NSC developments

Working Party on Scientific Issues and Uncertainty Analysis of Reactor Systems

- ✓ Needs for Zero Power Reactors; HTGR physics
- ➢ AI in reactor physics modelling and simulation (M&S)
- ➢ HTGR physics

Working Party on Nuclear Criticality Safety

- ✓ Used fuel inventory; experimental needs for criticality safety
- ➢ Decay heat of irradiated nuclear fuels - a key metric for the back-end handling of fuel assemblies

Task Force on Demonstration of Fuel Cycle Closure including Partitioning and Transmutation (P&T) for Industrial Readiness by 2050

- ✓ High-level report; UK to host a report lunching event
- ➢ Development of a new Joint Project based on Task Force's outcome (see next slide)

Developing subject matter experts, SINUS

- ➢ The International School on Simulation of Nuclear Reactor Systems (SINUS) for students and young professionals

Working Party on Material Issues in Nuclear Fuels and Structural Materials

- ✓ Defining needs and priorities for the working party
- ➢ Bridging fuel/material M&S and experimental data
- ➢ AI for M&S

Working Party on International Nuclear Data Evaluation Co-operation

- ✓ Nuclear data formats, strategic needs; development of JEFF library
- ➢ Nuclear data for Advanced Reactors
- ➢ Automatic workflows for nuclear data development

Working Party on Scientific Issues of the Advanced Fuel Cycles

- ✓ Fuel recycling and waste technologies; advanced fuel cycles scenarios; innovative fuels; and reactor coolants/components
- ➢ Chemistry of fuel cycles for Molten Salt Reactors
- ➢ Task Force on acceleration of fuel qualification process

Knowledge management

- ➢ Renewed demand for the NEA reactor physics handbook, including UK Dounreay Fast Reactor data

- ✓ Areas of current UK engagement
- ➢ What else could be of interest that not currently engaged with?

Summary: latest separately funded projects

Ongoing projects

Testing fuels for Advanced Reactors, FIDES-II
Planning experimental campaign around HTGR fuel

Qualifying LWR fuels, FIDES-II, QUENCH-ATF
- Testing ATF/high-burnup fuels and claddings
- Testing advanced materials
- Preserving experimental data
- Advancing modelling and simulation

Building human capacity, the Global Forum on Nuclear Education
The first international standing body of nuclear science and technology academics, focusing on modernisation of nuclear education

Developing subject matter experts, NEST
Hands-on training for students to work at international facilities not available in the UK on 'hot' topics, including:
- SMRs; robotics and AI for legacy decommissioning
- Interest in UK leading on training, courses and access to operating and in-flight decommissioning of Graphite cooled Reactors

Projects under development

Accelerating fuel qualification
Proposing route for acceleration of new fuels' qualification using disruptive technologies

Demonstrating fuel cycle closure
- Testing advanced technologies for separation, fabrication and reprocessing at a laboratory scale
- Irradiating fuels with minor actinides at ATR, US, and at JOYO, Japan (the only Fast test Reactor available for western countries)

Proposing advanced waste routes, WISARD
Developing international route for characterisation, transport, storage, conditioning and disposal of spent advanced (TRISO) fuels

Building a pipeline of professionals
Engaging with high-school students to consider STEM or nuclear education at the university level

Knowledge management
Analysing legacy experimental data, including DRAGON and AGRs data

Looking ahead

- Expanding importance of the education mission through NEST and the Global Forum.
- Leveraging outputs of NSC activities and NEA in-house expertise into practical materials and trainings for academia and young professionals.
- Preserving experimental data and ensuring this data can support modern simulation and modelling infrastructure.
- Developing further data, tools and methodologies to support V&V and licensing of advanced reactor concepts and SMRs.
- Pursuing studies in the front and back ends of the fuel cycle to support potential deployment of advanced reactors.
- Centralising expertise, experimental capacities and know-how to provide the efficiency required to accelerate development of new and innovative fuel and materials.

Thank you for your attention!

All NEA publications and institutional documentation available at

www.oecd-nea.org