NEA
NUCLEAR ENERGY AGENCY

Accelerating international cooperation on SMR safety research

Using opportunities and gaining advances in safety assessment and validation of computer codes through NEA frameworks

Vesselina Ranguelova
OECD-NEA, Deputy Head of the Division of Nuclear Safety Technology and Regulation
Martina Adorni
OECD-NEA, Nuclear Safety Specialist, Division of Nuclear Safety Technology and Regulation

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Content

- OECD-NEA background

- NEA achievements and perspectives: a focus on safety of SMRs
  - Expert Group on SMR – establishment and achievements
  - NEA activities on TH Computer Codes V&V
  - NEA work on reliability of Passive Systems

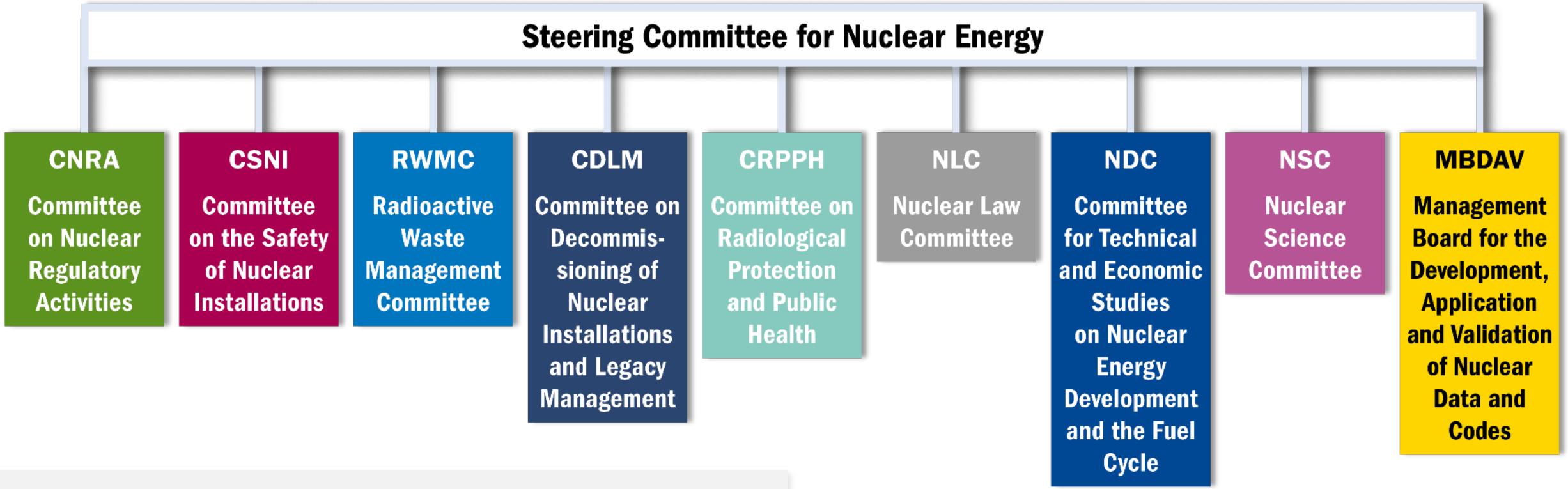
- SMR to fit in the NEA Thematic Research Platforms

- Conclusive remarks: NEA facilitating international cooperation on SMR safety research

NEA member countries

The NEA's current membership consists of 34 countries in Europe, North America and the Asia-Pacific region. Together they account for approximately 82% of the world's installed nuclear capacity.

NEA committees (as of 1 January 2024)

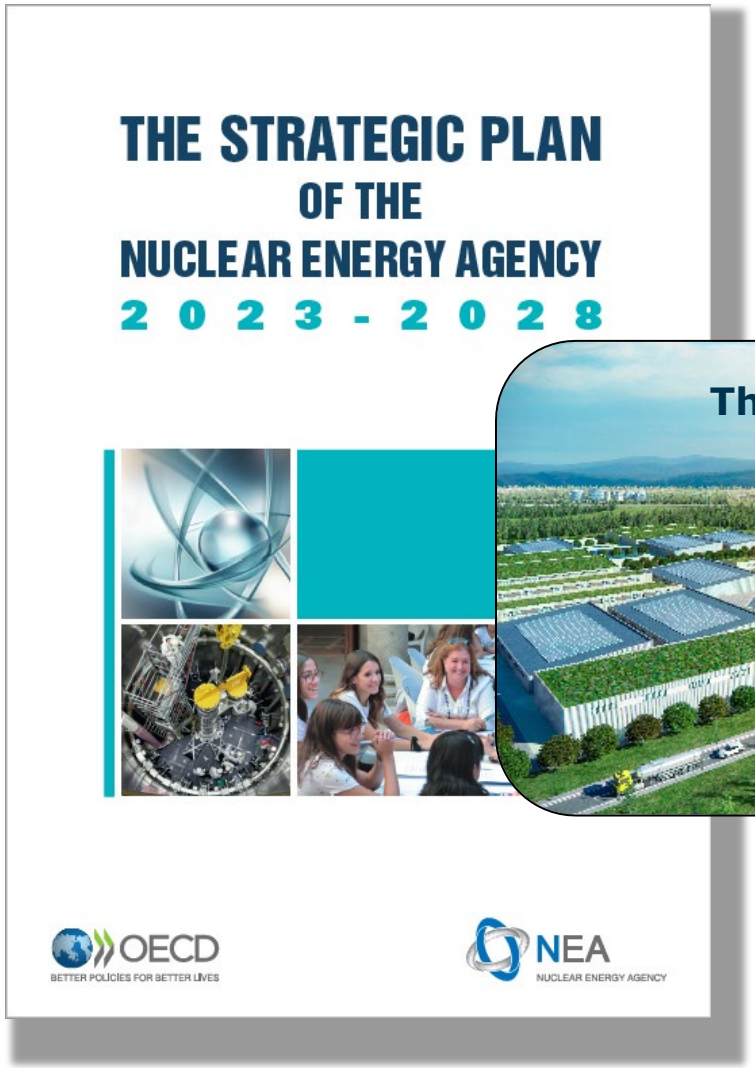


8 standing technical committees

1 management board

≈74 working parties and expert groups

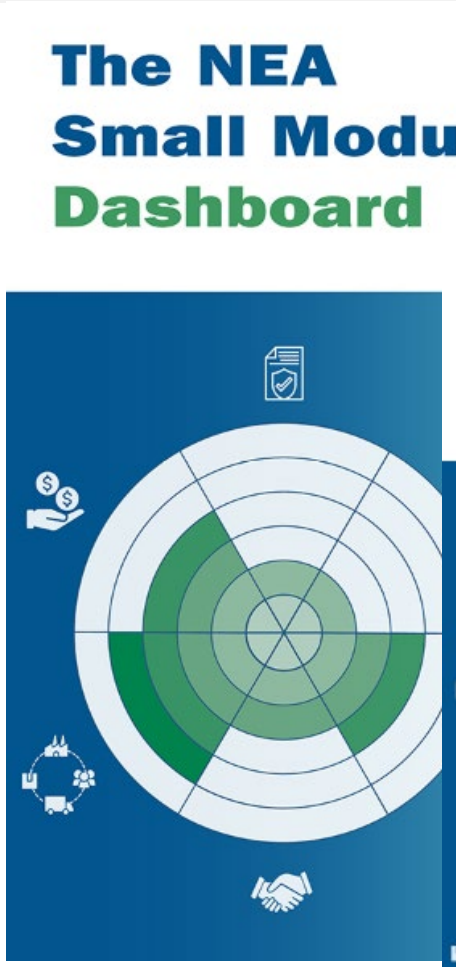
NEA Steering Committee for Nuclear Energy (SC) endorsed the new Strategic Plan and NEA SMR Strategy

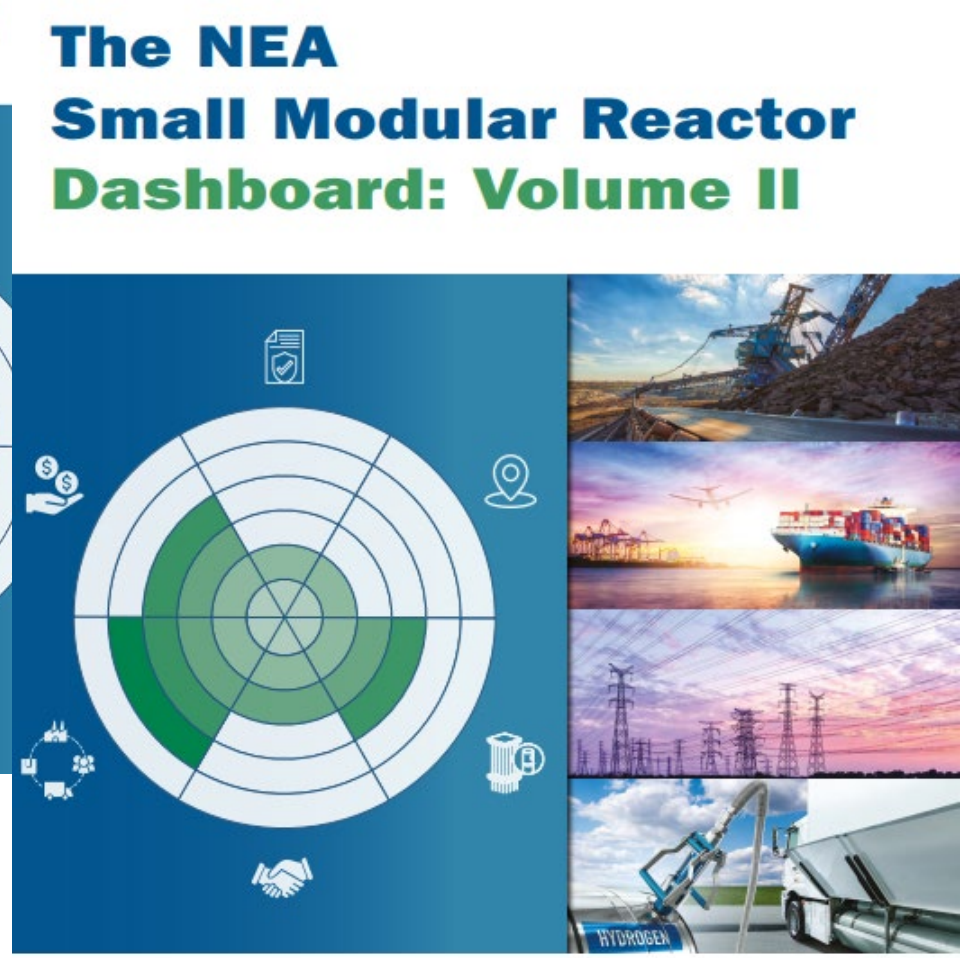


https://www.oecd-nea.org/jcms/pl_88539/accelerating-smrs-for-net-zero

The NEA SMR Dashboard (Volume I and II)

- **42** Designs included
- Readiness presented on:
  - Licensing;
  - Siting;
  - Financing;
  - Supply Chain;
  - Engagement;
  - Fuel
- **Volume III** to be published in 2024

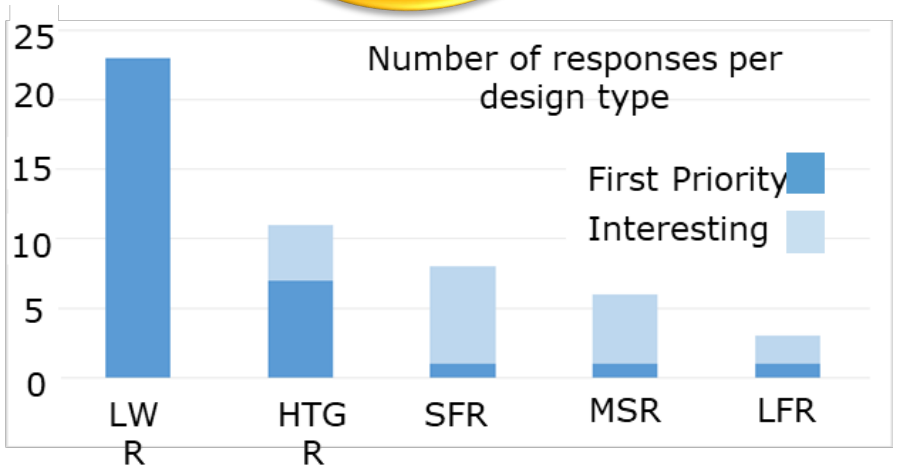




https://www.oecd-nea.org/upload/docs/application/pdf/2023-02/7650_smr_dashboard.pdf

Safety of Small Modular Reactors

NEA Expert Group on SMR



1. Support safety assessment for **Regulators**
2. Cross cutting safety issues to ensure robust **DiD** for SMR
3. PIRT& Code **V&V** Matrix
4. SMR **Safety Research**

Download the report at: oe.cd/5fw

Future programme under elaboration (periodic SMR safety review events)

Coordination with IAEA in progress, including on IAEA NSHI

Safety of SMRs : Key, Short-term Actions

1

- Gathering SMR **P**henomena **I**dentification and **R**anking **T**ables (**PIRTs**) to identify SMR safety phenomena and prioritise future efforts

2

- Starting work on the high-priority **cross-cutting issues**
  - DiD when passive safety applied at multiple levels
  - EPZ, human factors, multi-unit/multi-module impact on safety
  - transport, floating
  - Associated process: H2, process heat

3

- Reviewing and updating the **CSNI Code Validation Matrix (CCVM)** for SMR safety, and producing **guidance reports on V&V needs** for code qualification

4

- Collecting and generating data through **joint research projects** to support SMR safety

CSNI Code Validation Matrix (CCVM) (1/2)

Gathers **the largest set of available experimental test data (initially in TH domain)** in matrix for various technology and reactor design including

- Quantification of uncertainties
- Relevant phenomena dominating different types of accidents and transients / **PIRT**
- Phenomena occurrence vs **experimental facilities**
- Suitability of the experimental facilities, thus databases, for **code assessment**

Matrix I

CROSS REFERENCE MATRIX FOR LARGE BREAKS IN PWRs

- Phenomena versus test type
  + occurring
  o partially occurring
  - not occurring
- Test facility versus phenomenon
  + suitable for code assessment
  o limited suitability
  - not suitable
- Test type versus test facility
  + performed
  o performed but of limited use
  - not performed or planned

		Test Type			Test Facility and Volumetric Scaling						
		Blowdown	Refill	Reflood	CCTF 1:25	LOFT 1:50	BETHSY 1:100	PKL 1:145	LOBI 1:712	SEMISCALE 1:1600	UPTF 1:1 (a)
Phenomena	Break flow	+	+	+	+	+	+	+	+	+	+
	Phase separation (condition or transition)	o	+	+	+	+	+	+	+	+	+
	Mixing and condensation during injection	o	+	+	o	o	o	o	o	o	+
	Core wide void + flow distribution	o	+	+	o	o	o	o	o	-	o
	ECC bypass and penetration	o	+	o	o	+	-	o	o	-	+
	CCFL (UCSP)	o	+	+	o	o	o	o	o	-	+
	Steam binding (liquid carry over, etc.)	-	o	+	o	o	-	o	o	o	o
	Pool formation in UP	-	+	+	o	o	o	o	o	o	+
	Core heat transfer incl. DNB, dryout, RNB	+	+	+	+	+	+	+	o	o	-
	Quench front propagation	o	o	+	+	+	+	+	-	+	-
	Entrainment (Core, UP)	o	o	+	o	o	o	o	o	o	+
	Deentrainment (Core, UP)	o	o	+	o	o	o	o	o	o	+
	1 - and 2-phase pump behaviour	+	o	o	-	o	-	o	+	+	-
	Noncondensable gas effects	-	o	o	-	+	+	-	-	-	+
Test Facility	CCTF	-	o	+							
	LOFT	+	+	+							
	BETHSY	-	-	+							
	PKL	o	+	+							
	LOBI	+	+	-							
	SEMISCALE	+	+	+							
	UPTF	o	+	+							

Important test parameter
- break location/break size
- pumps off/pumps on
- cold leg injection/combined injection

(a) UPTF integral tests

Consensus that these matrices constitute a **commonly recognised set of data for code validation**

CSNI Code Validation Matrix (CCVM) (2/2)
Development, Update & Extension **need resources**

Assess the **adequacy, quality and completeness** of the **experimental database** to properly characterise the behaviour of new advanced designs and to validate simulation tools

Current **SET**:
185 test facilities
1094 tests identified
67 thermal-hydraulic phenomena, now **116**

1994

- Established in **1987** for LWR: for integral effect tests (**ITF**) and separate effects tests (**SET**)
- Supplemented later for **VVER** and severe accidents, such as **in-vessel** core degradation and **containment** phenomena

2023 1st review of the content

- **Necessary update** for existing nuclear reactors and related technologies
- **Necessary extension** to emerging challenges of evolutionary and innovative reactor designs and nuclear technologies, **including SMRs**
- **Cooperation with IAEA NHSI initiative**: collaborative network, workshops

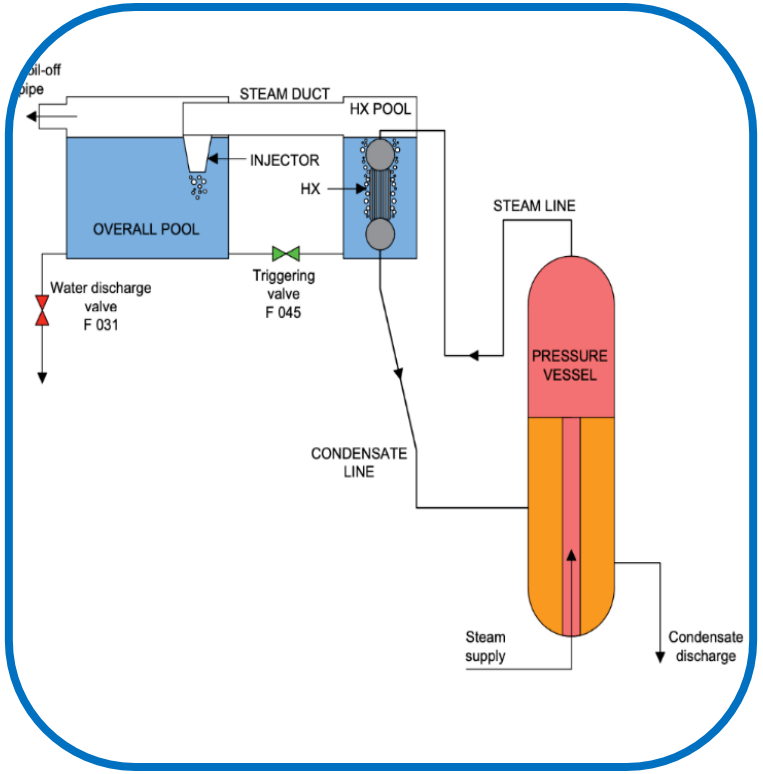
Perspectives

NEX SHARE

Assessment of reliability of Thermal-Hydraulic Passive Systems supported by adequate Validation of simulation codes

- **Status report on thermal-hydraulic passive systems design and safety assessment, volume 1** ***NEA/CSNI/R(2021)2***
  - Care must be taken to ensure suitable analysis of adequacy in the design and operation of passive T/H system

- **BENCHMARK: Final Report on the PERSEO benchmark exercise, volume 2** ***NEA/CSNI/R(2021)2/ADD***
  - Ability of codes to predict natural circulation and assessment of areas for attention



Source: PERSEO Facility, ENEA

There is a need to develop suitable **internationally recognized guidelines** for assessing the **reliability of passive systems**

NEA High Level Nuclear Safety Research Roadmap

PIRTs for innovative designs and phenomena related to LTO issues

Organize a **R&D and databases framework model**

Establish a safety **research board – road map**

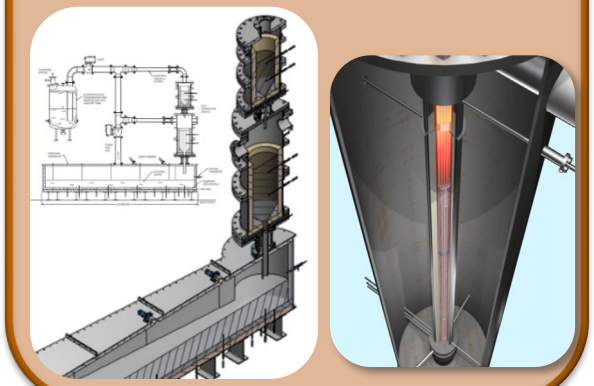
Engaging with **policy making** bodies

- https://www.oecd-nea.org/jcms/pl_72839/nea-nuclear-safety-research-joint-projects-week-success-stories-and-opportunities-for-future-developments

SMR to fit in NEA Thematic Research Platforms

Fuel Safety: FIDES II

TH and SA platforms



Structural material Platform

Waste Management: WISARD

NEA safety research to be a major part of the work:

- Setting **platforms** with OA
- Setting research **priorities** based on PIRT/ CSNI WG studies/ RB needs
- Identifying need for new research **infrastructure**
- Setting QA/Terms of Reference for **quality experiments**
- Executing common research / benchmarking to **V&V computer codes** and to improve safety knowledge
- NEA Data Bank to **preserve data**

Figure sources: ANL, KIT, Studsvik

The example of Thermal-hydraulic data, models and tools

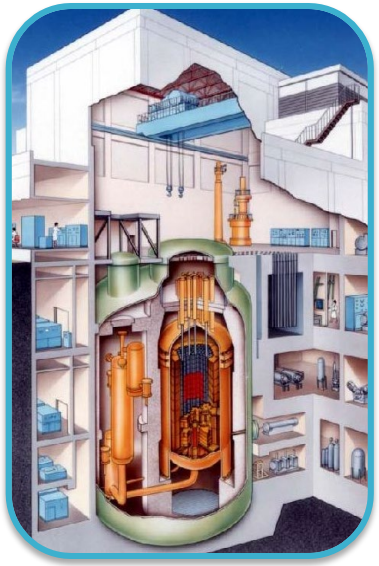
LOFC (2011-2027, 7 countries)

RBHT II (2023-2026, 10 countries)

ATLAS-3 (2021-2024, 10 countries)

ETHARINUS (2020-2024, 14 countries)

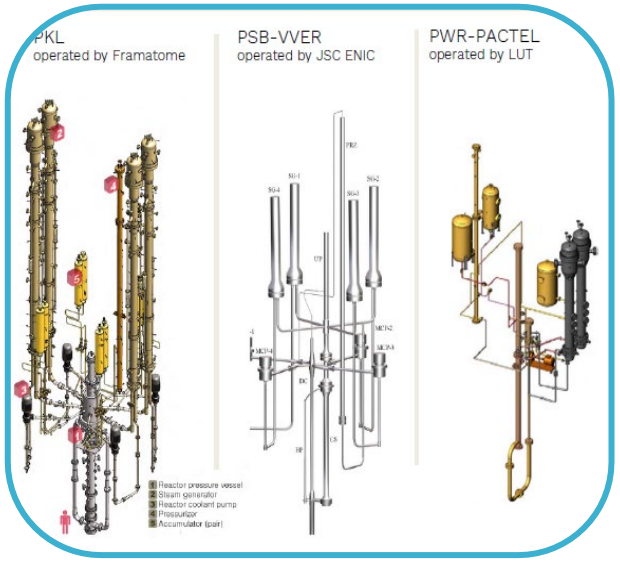
POLCA (2024-?) **NEW**



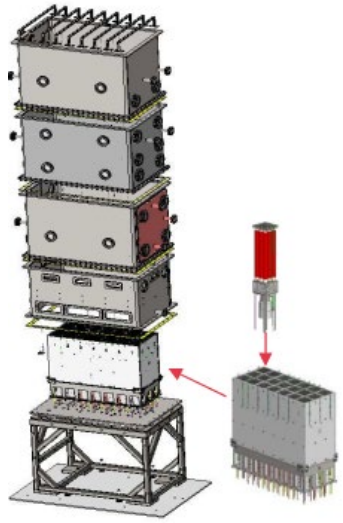
JAEA HTTR reactor
Restart in 2021

RBHT Test Section
Figure source Penn. State University

ATLAS facility
Figure source KAERI



PKL (Framatome)
PSB-VVER (JSC ENC)
PWR-PACTEL (LUT)

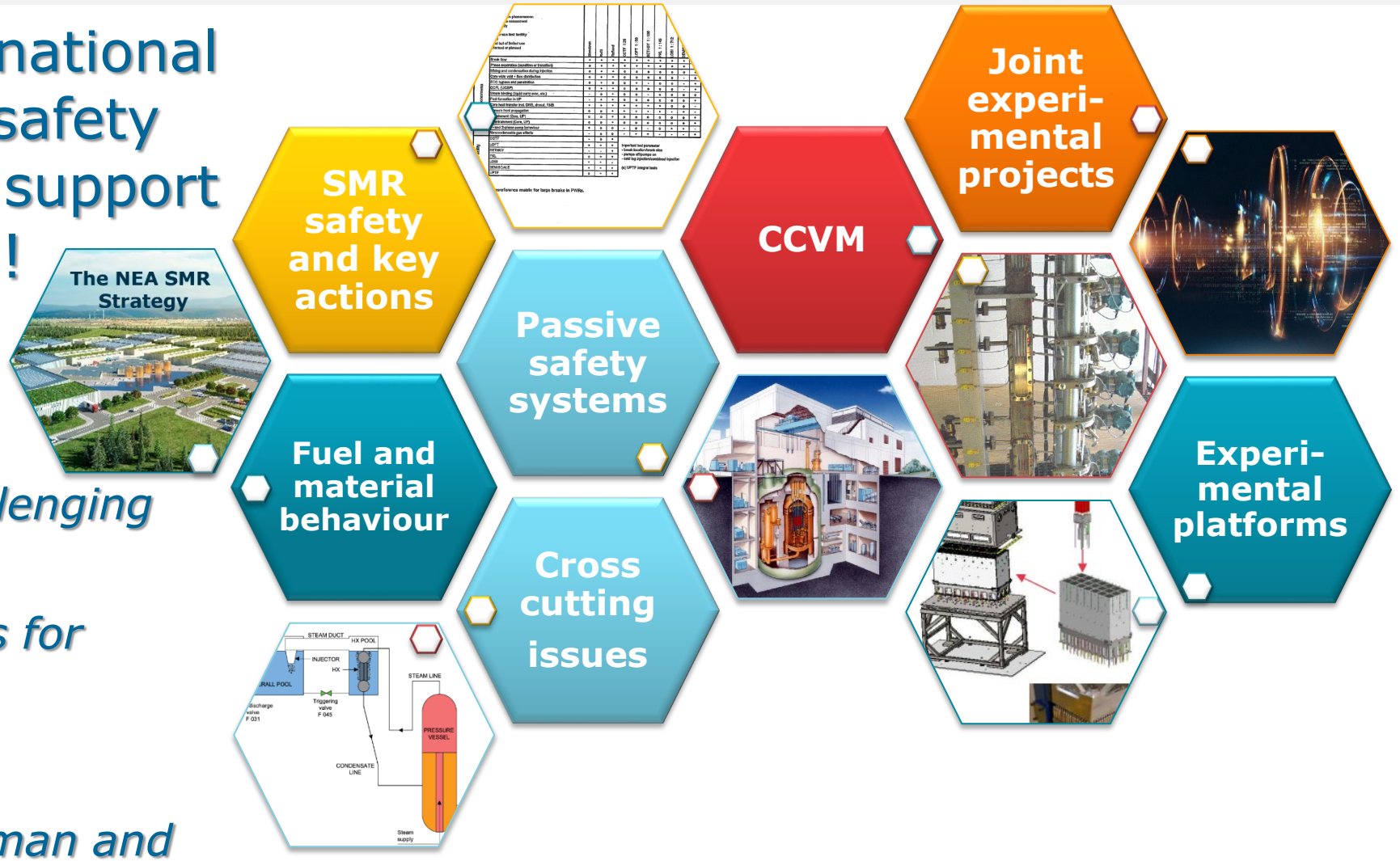


MIDI Test Section
Figure source IRSN

Towards a new platform of research Facilities for **TH and SA safety related joint projects** that could also meet the research needs for **SMRs**

Conclusive remarks

Let's accelerate international cooperation on SMR safety research together to support safety harmonisation!



Through:

- *Common position on challenging safety issues*
- *Consensus methodologies for safety assessment*
- *Joint safety projects*
- *Effective utilisation of human and financial resources*

Thank you for your attention

Vesselina Ranguelova

Deputy Head of Nuclear Safety Technology and Regulation Division

Nuclear Energy Agency (NEA)

+33 674 89 33 91

Vesselina.RANGUELOVA@oecd-nea.org

www.oecd-nea.org