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INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

INPRO Collaborative Project: Legal and Institutional Issues for Prospective Deployment of Fusion Facilities

"INPRO Fusion Study"

Technical Meeting on Compatibility Between Coolants and Materials for Fusion Facilities and Advanced Fission reactors

30 October-03 November 2023, Vienna

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NENP INPRO Section

INPRO – International Project on Innovative Nuclear Reactors and Fuel Cycles

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International Project on Innovative Nuclear Reactors and Fuel Cycles

Key Programme of the IAEA

- Forward looking programme
- Covers lifecycle, >100 years
- Membership-based project
- Supports members in long-term planning and collaboration on innovations in nuclear power reactors, fuel cycles and institutional approaches
- Promotes sustainable development of nuclear and innovative energy systems

INPRO Members

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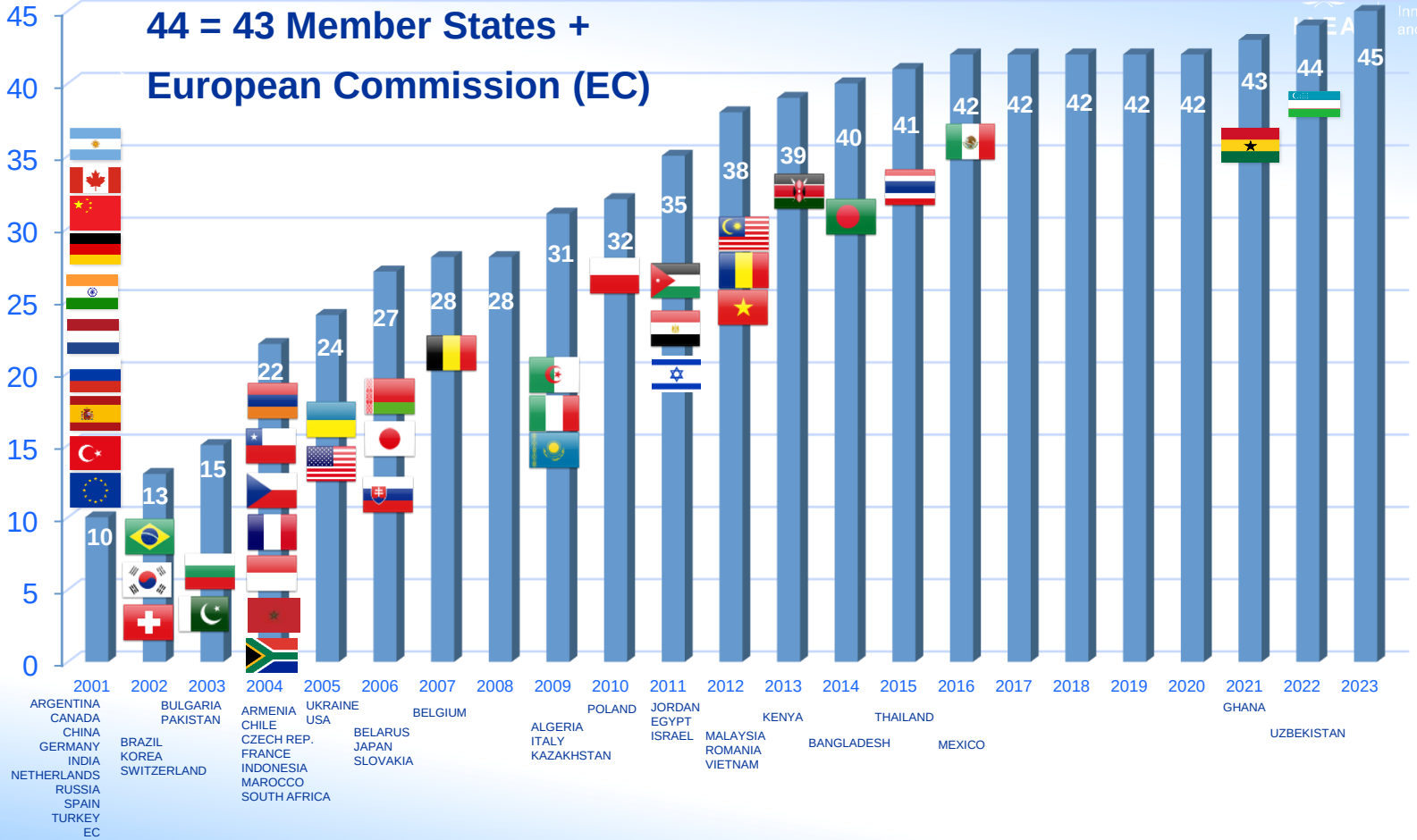
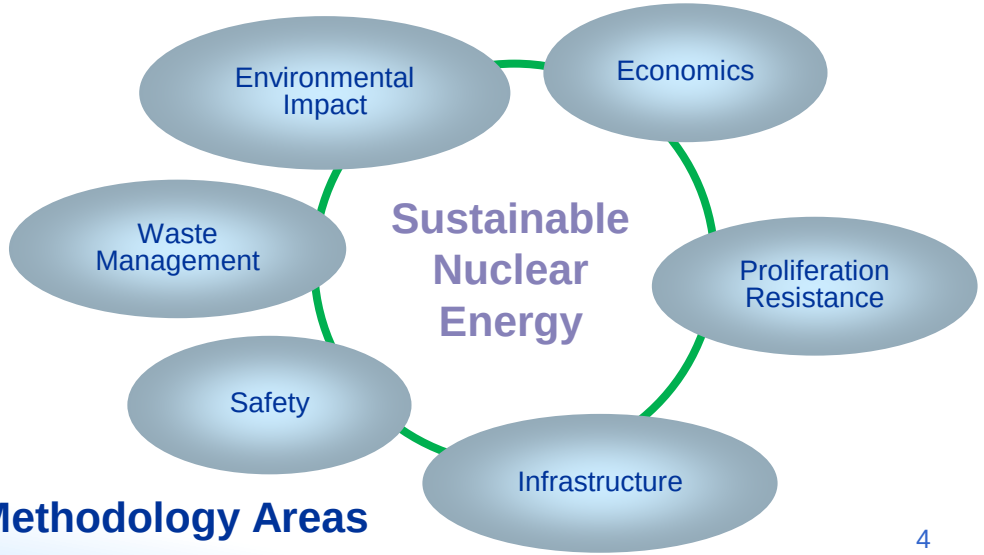


INPRO Objectives

- Ensure nuclear energy is available to contribute, in a sustainable manner, to the growing energy needs of the current century and beyond

- Bring together all interested Member States in joint international and national innovation tasks in nuclear reactors and fuel cycles promoting sustainability in 6 areas



INPRO Methodology Areas

Initiating the Project

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Initiated by

Recommendations of INPRO Member States

IAEA General Conference (GC) resolutions

Nov 2021: 30th INPRO SCM approved initiating project

Nov 2022: 31st SCM approved current scope

Interdisciplinary study

More than 20 international experts

6 countries and 1 international organization (ITER)

more than 20 IAEA staff from 10 Divisions and Sections

Progress

Held 6 formal meetings

Dozens of working group meetings

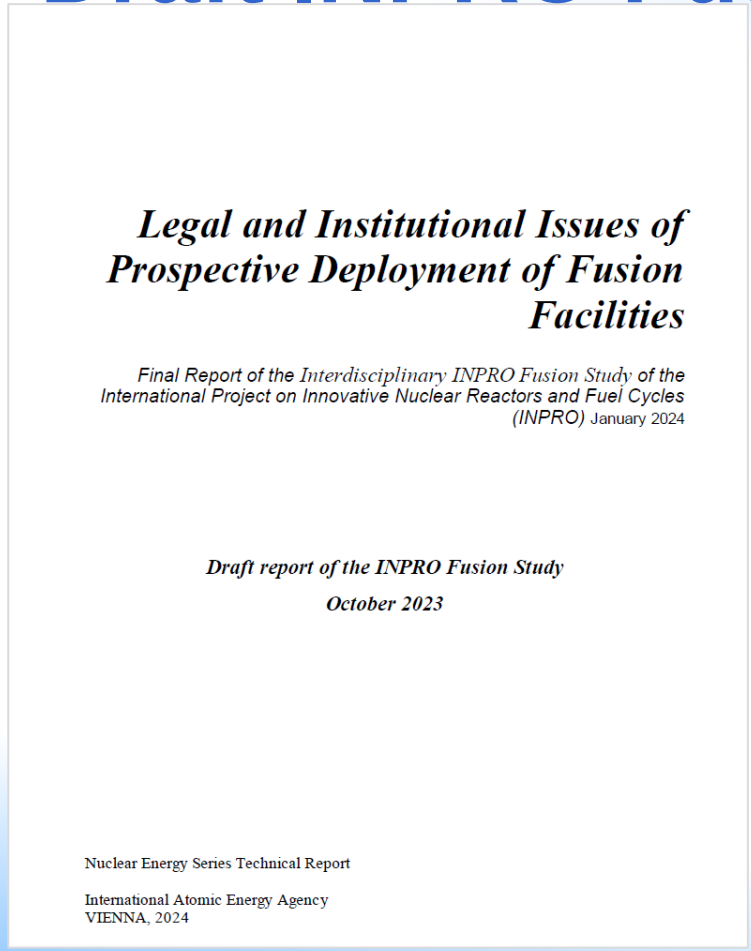
Next: Consultancy meeting Nov 2023

Objectives

Objectives are to:

- Support Member States in planning for the licensing, construction, and operation of First-of-a-kind commercial fusion powered facilities and integrated fusion-fission systems over the next decades
- Support Fusion community in its effort to accelerate the development and implementation of fusion based facilities and integrated fusion-fission systems, with the early identification of possible gaps in long-term sustainability and needed capabilities utilizing INPRO assessments and analyses

Draft INPRO Fusion Study Report



Legal and Institutional Issues of Prospective Deployment of Fusion Facilities

Final Report of the Interdisciplinary INPRO Fusion Study of the International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) January 2024

Draft report of the INPRO Fusion Study

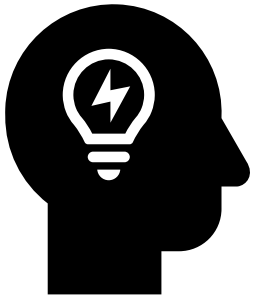
October 2023

Nuclear Energy Series Technical Report

International Atomic Energy Agency
VIENNA, 2024

- Long-term sustainability
- Role in adaptation to climate change
- Fusion fuel cycles
- Resource availability
- Legal challenges
- Safety issues
- Civil liability
- Nuclear security
- Regulatory classification
- Safeguards and non-proliferation
- Key export/import issues
- Fusion potential for nuclear transmutation
- “Gigafactory” production of facilities and licensing
- Human capacity building
- Project & quality management systems

Preliminary Findings: 8 Key Areas for Implementation



1. Long-term Sustainability
2. Legal Aspects and Challenges
3. Safety
4. Civil Liability
5. Nuclear Security
6. Safeguards and Non-proliferation
7. Key Export/Import Concerns
8. Additional Considerations

1. Long-term Sustainability

- Advantages of fusion: no carbon emissions, avoidance of severe accidents, large fuel reserves, proliferation resistance, and the absence of high-level waste
- Concerns issues: breeding of nuclear materials, some materials in fusion systems could become scarce on a long timescale. [Governments can begin to take action to address material shortages.]
- Contribution of fusion power in Net-Zero scenario. Drivers and challenges
- Resource availability for future fusion power systems
  - low resource availability problem. However, the relative supply risk for materials like tungsten, molybdenum, lithium, beryllium, and tantalum is higher than other low-carbon technologies.
  - a resilient, robust, and consistent energy system requires closed-loop material concepts, efficient recycling technologies, and a low resource vector.

2. Legal Aspects and Challenges

- The regulatory will play a critical role in the deployment of fusion facilities

  Licencing: “radiation sources” versus “nuclear installations.”
  - Short-term: radiation source framework is appropriate for licensing through the 2030s.
  - Longer term: may be appropriate to develop a tailored framework for fusion

- Licensing consideration for mass production: licensing timelines; deployment in different models: smaller component sizes, reduced site work, simplified manufacturing pathways, etc.

- Global harmonization on basic principles, particularly choice of frameworks, would aid fusion deployment and public safety

3. Safety

Pure fusion facilities:

- National regulatory regimes classify systems differently (i.e., as “radiation sources,” “nuclear installations,” or mixed)
- Align national regulatory regimes towards a consistent framework
- Consider harmonisation of fusion regulations as experience is gained in operating fusion facilities
- Develop a regulatory framework for safety based on experience from experimental fusion facilities

Hybrid fusion systems (using fusion and fission processes)

- Should consider experiences from regulating safety at nuclear fission installations
- The main systems and processes are the same with the pure fusion plants and still differ significantly from the nuclear fission reactors. The closest analogue are subcritical nuclear assemblies
- Reliance on special nuclear material alters the hazard makeup, and regulation under a nuclear installation framework may be appropriate depending on the quantity of nuclear material (source or special fissionable material) present.
- Fusion potential for waste transmutation, including fission-fusion hybrids for breeding, fusion induced transmutation of minor actinides and fission products

4. Civil Liability

The very low probability of a major nuclear accident, the low risks posed by fusion facilities, and the limited potential transboundary damage:

- Does not justify the inclusion of fusion installations within the scope of the international liability regime
- Applying fusion facilities to the current global regime would require amendment to the core conventions and treaties
- Developers may be able to obtain nuclear liability insurance in commercial markets

5. Nuclear Security

- No IAEA safety standards or guidance for fusion facilities

- The IAEA nuclear security series are considered to provide an excellent resource for designers and regulators of fusion facilities such as FPPs.

6. Safeguards and Non-proliferation

- Currently the IAEA does not apply safeguards to fusion systems that do not include nuclear material.
- For fusion systems that use nuclear material, the nuclear material and system could be subject to IAEA safeguards under a State's safeguards agreement,

  [i.e., comprehensive safeguards agreement (CSA), voluntary offer safeguards agreements (VOA) or item-specific agreement].

7. Key Export/Import Concerns

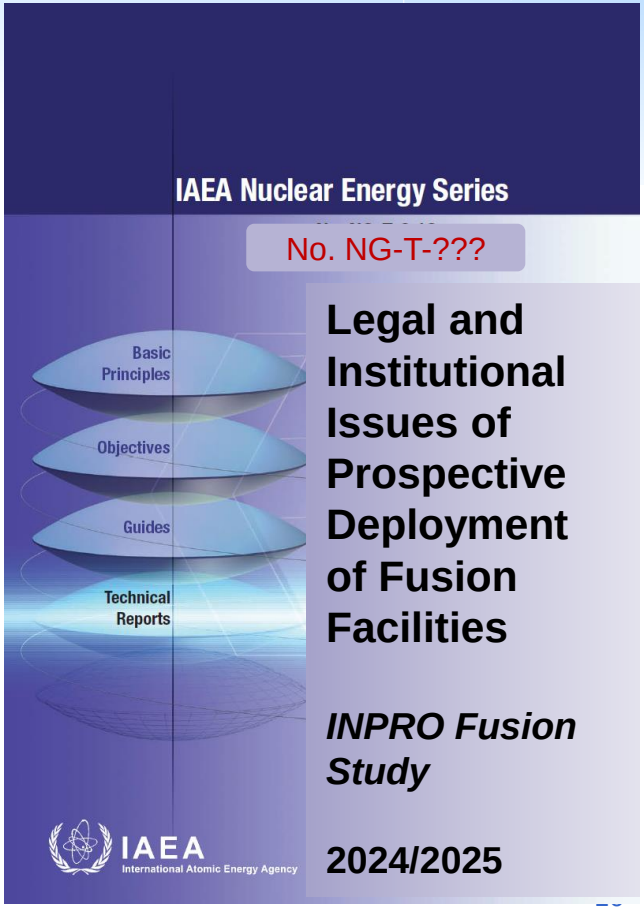
- Dual-use concerns are addressed in IAEA publications:
  - ‘Guidelines for the Export of Nuclear Material, Equipment and Technology’
  - ‘Guidelines for Transfers of Nuclear-Related Dual-Use Equipment, Materials, Software, and Related Technology’

  under IAEA INFCIRC/254 Part 1 and Part 2 respectively..
- Export control guidelines and lists are subject to regular updates, and therefore further items of relevance to fusion may be included in future revisions
- Many States also apply catch-all controls, allowing to require an export license for items and technology not listed on export control lists, e.g., when there is an end-use or end-user concern

Fusion Study Conclusions

- Provides insights into legal and institutional challenges
- Addresses challenges and opportunities for deployment
- Aims to support the development of legal frameworks for fusion energy

Harmonizing regulations, ensuring safety and security, and addressing resource availability are vital steps toward realizing fusion's potential as a clean and sustainable energy source



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Thank you!