

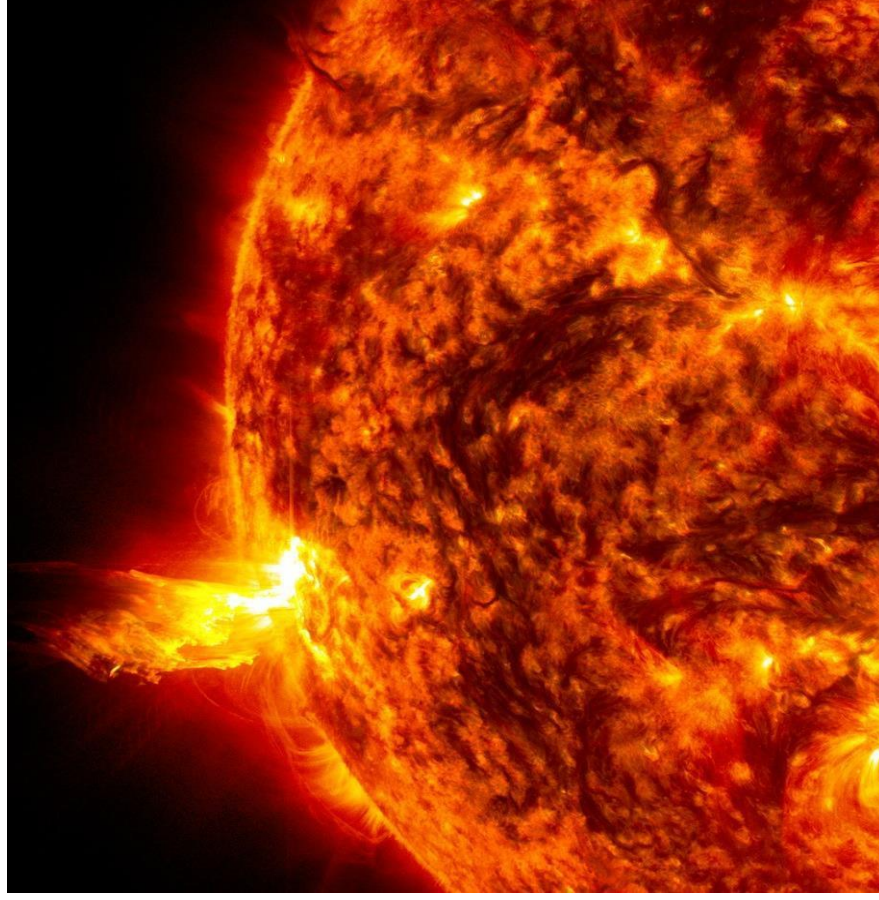
Cross-cutting aspects of safety, security, and legal issues for Deployment of Fusion Plants

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ABSTRACT

Objective Of INPRO Fusion Study:

to support the fusion community in its effort to accelerate the development and implementation of fusion based facilities and integrated fusion-fission (hybrid) systems, with the early identification of possible gaps in long-term sustainability and needed capabilities utilizing INPRO assessments and analyses.



General topics discussed: long-term sustainability issues; main drivers and impediments to deployment of fusion facilities and hybrid energy systems; legal issues and challenges, international conventions and instruments, national legislations and liability; fusion safety and security issues; comprehensive infrastructure issues; identification of findings and gaps

Achieved through cooperative work on cross-cutting issues conducted by the IAEA and INPRO Member States, along with inter-departmental IAEA cooperation: 6 countries, ITER, more than 40 experts and 10 IAEA divisions and sections.

PURPOSE

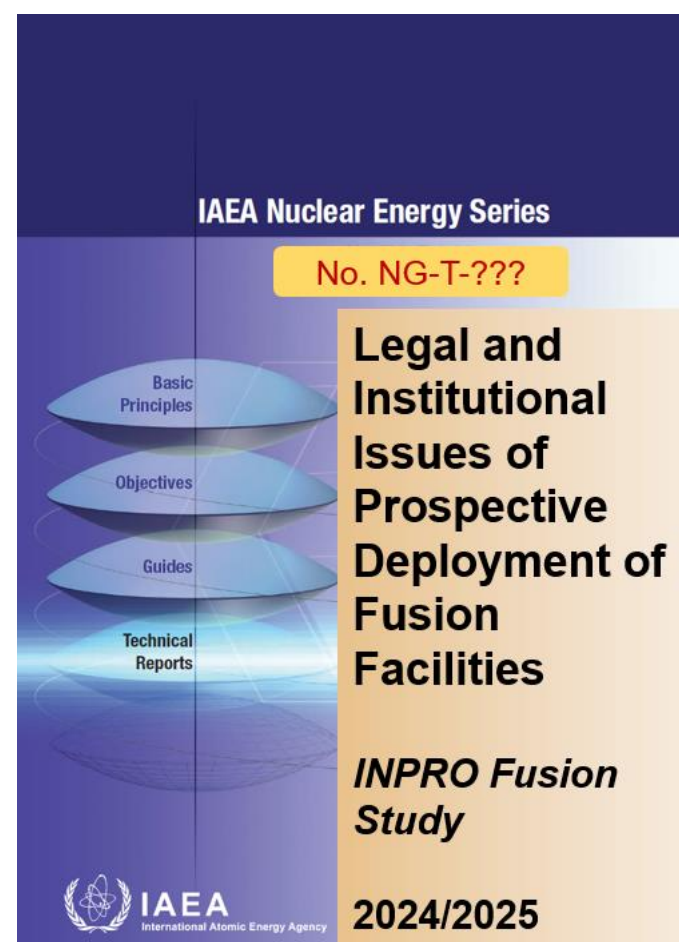
To support Member States in:

- (i) planning for the licensing,
- (ii) construction, and operation of First-of-a-kind commercial fusion powered facilities and integrated fusion-fission systems over the next decades.

To support Fusion community in its effort:

- (i) to accelerate the development and implementation of fusion based facilities and integrated fusion-fission systems,
- (ii) with early identification of possible gaps in long-term sustainability and needed capabilities utilizing INPRO assessments and analyses.

This INPRO Fusion Study Report is in final draft stage and in the publication process as an IAEA Nuclear Energy (NE) Series document.

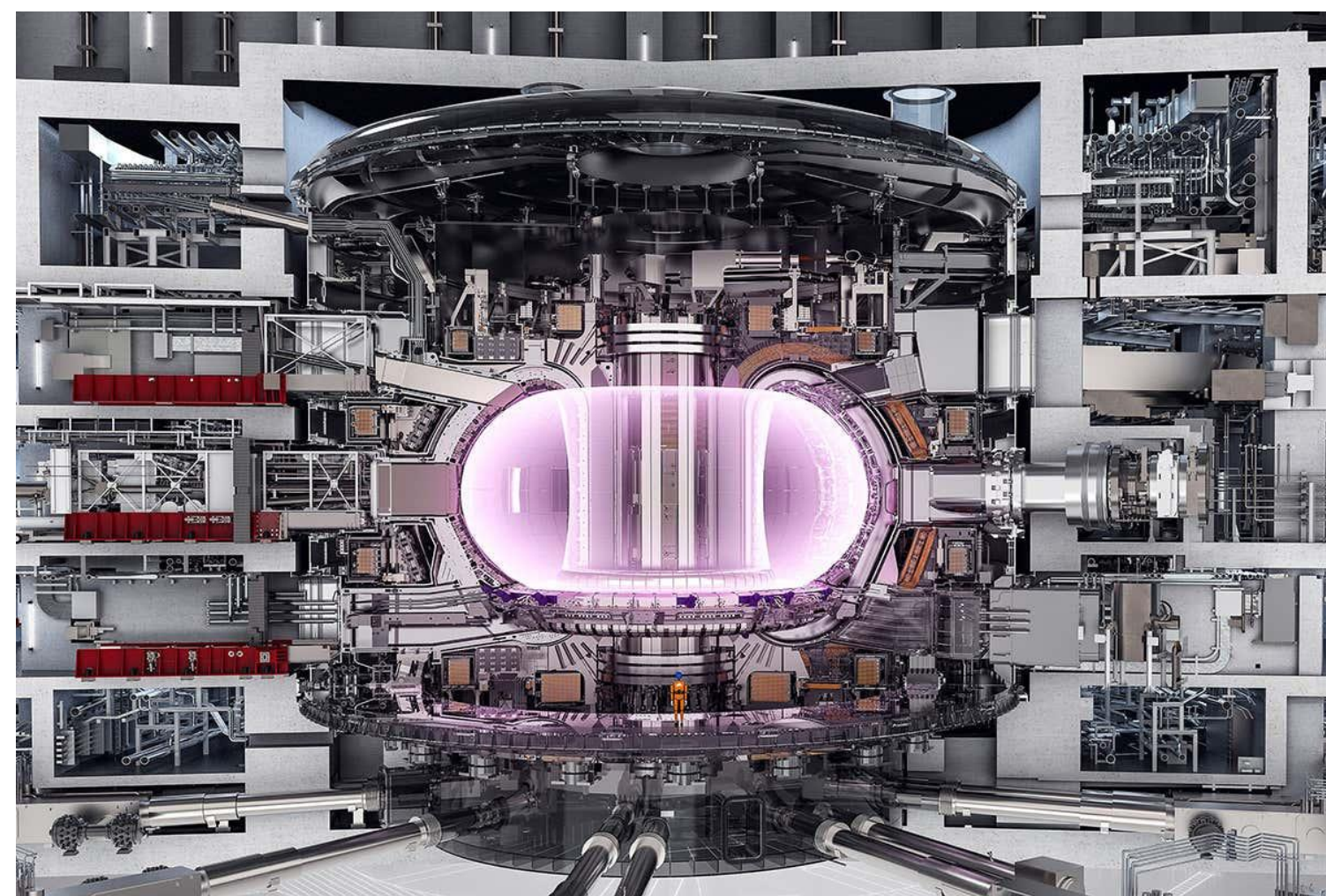


INPRO Methodology Areas

The INPRO Methodology applied in this study was developed over two decades since 2000 with contributions from over 300 international experts, assesses sustainability in six key areas: economics, environment, safety, waste management, proliferation resistance, and infrastructure.

Involvement and Participation

More than 20 international experts, 6 countries and 1 international organization (ITER), more than 30 IAEA staff from 10 Divisions and Sections.



KEY AREAS & FINDINGS (Fusion Study)

Long-term Sustainability

Advantages: Fusion power contributes to meet net-zero goals.

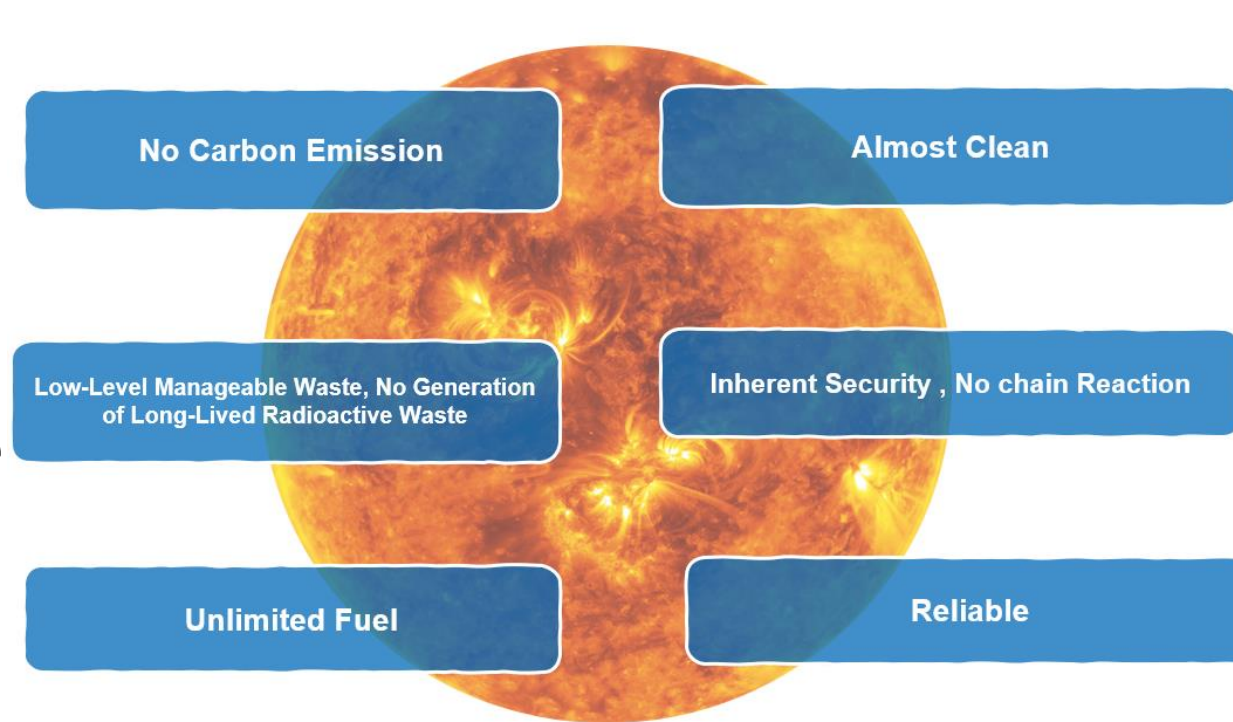
Concerns: breeding of Tritium, some materials in fusion systems could become scarce on a long timescale.

Legal Aspects And Challenges

Licensing: “radiation sources” versus “nuclear installations.”

- Short-term: radiation source framework is appropriate for licensing through the 2030s
- Long-term: may be appropriate to develop a tailored framework for fusion.

Advantages of Thermonuclear Energy



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):

- Apply experiences from regulating safety at nuclear fission installations

CIVIL LIABILITY

- Low risks of major accidents and limited potential transboundary damage.
- However, this alone does not justify their inclusion in the international liability regime.
- Applying fusion facilities to the current global regime would require amending core conventions and treaties.
- Developers may explore obtaining nuclear liability insurance from commercial markets.

NUCLEAR SECURITY

- The IAEA Nuclear Security Series could be an excellent resource for designers and regulators of fusion facilities

SAFEGUARDS AND NON-PROLIFERATION

- Fusion plants that do not use, process, or produce nuclear material are less attractive for proliferation compared to fission nuclear facilities.
- The IAEA currently applies safeguards only under an Additional Protocol to fusion systems that do not handle nuclear material.
- Fusion plants may be subject to safeguards under comprehensive safeguards agreements (CSAs), Voluntary Offer Agreements (VOAs), or item-specific safeguards, depending on the scenario.
- Further assessment is needed to determine if IAEA safeguards apply more broadly to fusion energy systems.
- Tritium and lithium are not covered by existing safeguards agreements.
- Additional extrinsic measures include export controls, national material inventory programs, and safeguards applicable to nuclear material and facilities.

ADDITIONAL FINDINGS

- Public perception of fusion is important, including public information and engagement, energy justice, artificial intelligence for fusion, etc..

CONCLUSION. INPRO FUSION STUDY 2022-2024

- To accelerate the global transition to a green and circular economy, the IAEA initiated activities to explore areas of synergy between fusion and fission technologies to help them become vital players in the coming decades.



- The IAEA's traditional mechanism for gathering information through technical meetings reveals some features that could be considered in shaping future IAEA activities and inviting new stakeholders.
- 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.
- Transfers of Nuclear-Related Dual-Use Equipment, Materials, Software, and Related Technology' under IAEA INFCIRC/254 Part 1 and Part 2 respectively. Also, some States may have additional controls.