IAEA
International Atomic Energy Agency
Atoms for Peace and Development

INPRO Studies on Transportable Nuclear Power Plants and Modules: Key Findings and Challenges for Transportation and Regulations

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21st INPRO Dialogue Forum on the Deployment of Small Modular Reactor Projects and Technologies to Support the Sustainable Development Goals

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IAEA
INPRO
International Project on
Innovative Nuclear Reactors
and Fuel Cycles

Current INPRO Projects on SMRs

1. **Global Scenarios:**
   Collaborative project: "Analysis Support for Enhanced Nuclear Energy Sustainable Deployment Scenarios for SMRs" (ASENES SMR)

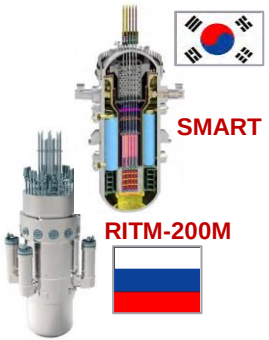
2. **Innovations:**
   Case studies for the Deployment of Factory Fuelled SMRs (Transportable NPPs)

3. **Sustainability Assessments & Strategies:**
   Nuclear Energy System Sustainability Assessments (NESA) for SMRs

4. **Dialogue Forums (DF):**
   - **17th INPRO DF: Opportunities & Challenges in SMRs,** July 2019 Ulsan, Republic of Korea, 143 participants from 22 Member States
   - **Current 21st INPRO DF**

ASENES

Scenario modelling and analysis	Economic analysis and evaluation of Nuclear Energy System (NES)	Comparative evaluation of NESs and scenario options	Road mapping towards enhanced NE sustainability
MESSAGE-NES	NEST	KIND-ET	ROADMAPS-ET



2019
17th DFs

2023
21st DFs

INPRO: Nuclear Innovations vs. legal and institutional drivers and impediments

Role of Nuclear innovations for Sustainable Development

SMRs and Transportable Nuclear power plants (TNPP)

Analysis of Legal and Institutional aspects of innovations deployment

INPRO Study of Legal and Institutional issues of TNPP

2008 - 2013

INPRO Case Study for the Deployment of a Factory Fuelled SMR (Transporatble)

2015 - 2023

INPRO collaborative project: Legal and Institutional Issues of Transportable Nuclear Power Plants: A Preliminary Study (TNPP-I)

The study was performed in 2008-2013 and documented in the Nuclear Energy Series Technical Report No. NG-T-3.5

Two Options were considered:

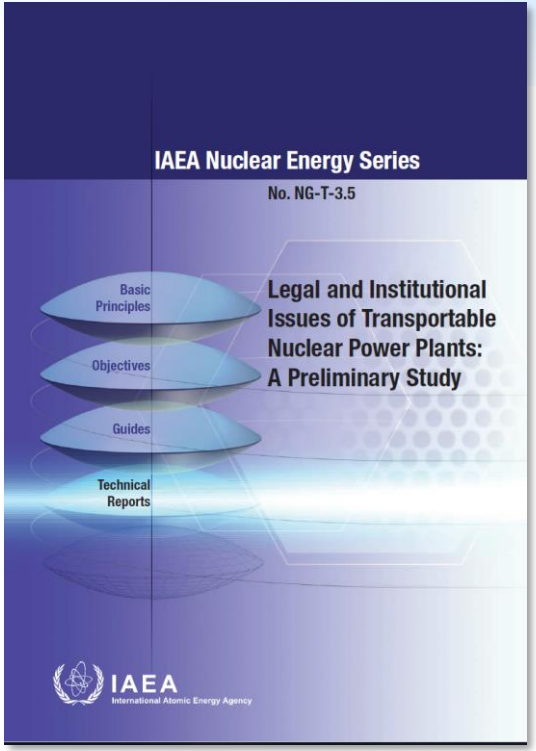
- Option 1: A TNPP, factory assembled, supplier factory fuelled and tested, supplier factory maintained and refuelled or decommissioned….
- Option 2: A TNPP, factory assembled, factory pre-tested (non-nuclear tested), maintained, fuelled and refuelled on-site…

Two scenarios:

- scenario 1: Supplier is operator/Host State is regulator.
- scenario 2: The Host State entity is operator/Host State is regulator.

Issues for consideration: **Infrastructure, safeguards, legal, nuclear safety and security, nuclear liability.**

- *When factory fueled reactors are to be used, there are obvious gaps and an insufficient coverage in the international nuclear law and in the non-binding international norms.*



Legal and Institutional Issues of Transportable Nuclear Power Plants: A Preliminary Study (1)

The main conclusions regarding Supplier States

A TNPP provides opportunities for innovative commercial arrangements that have the potential to **reduce the initial costs to a host**. A TNPP transported as a complete factory built power plant (the fuel transported separately and loaded).

A TNPP supplier may consider **several options**, such as leasing the TNPP, selling the TNPP with payment on delivery, operating the TNPP and selling the electrical output, the produced steam or any other products.

The Supplier will need to make a commitment to the Host State regulator, to enable access to the design details and safety case approved by the regulator of the supplier country.

The main conclusions regarding Host States :

Introducing a TNPP may **require fewer financial and human resources** from the Host State.

A TNPP may better match a **smaller electrical grid** and be deployed faster than a conventional NPP.

Host State needs to address are commitments to **establish appropriate nuclear legislation, liability undertakings, and a regulatory body.**

Host State will need to establish criteria for the site. Arrangements for environmental protection, emergency planning, security and physical protection should consider all phases of the TNPP life cycle.

Legal and Institutional Issues of Transportable Nuclear Power Plants: A Preliminary Study (2)

The main conclusions on international legal framework

- The applicability of the international legal instruments (conventions) on nuclear safety, nuclear security and liability for nuclear damage to TNPP transactions conducted by the States parties to these instruments needs careful consideration;
- International non-binding requirements and guidance established by the IAEA would apply to TNPPs.
- Option 2 (fuel is transported separately from the reactor) will not require any new legal instruments to be developed to cover transport.
- The analysis of the current state of the applicable international nuclear law and related regulations has shown that for the Option 1 for TNPP, there are obvious ‘gaps’ and an insufficient coverage of certain TNPP related activities.

Nuclear safety and nuclear security aspects for Option 1 (a TNPP are factory fuelled and tested) were recommended for further study and consideration.

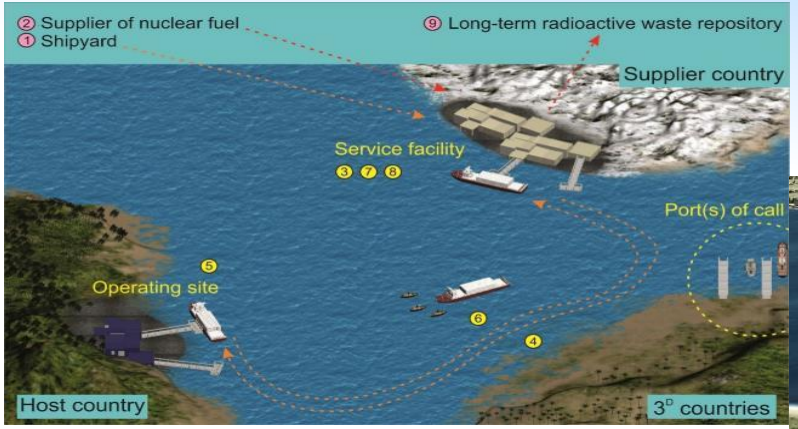
However, the existing legally binding norms and recommendations on nuclear security (physical protection) are of a generic nature.

Safeguards and verification issues for export transactions with TNPPs: there is nothing distinctive about the characteristics of the construction or operation of a transportable nuclear installation which would differentiate it from the construction or operation of a non-transportable nuclear installation.

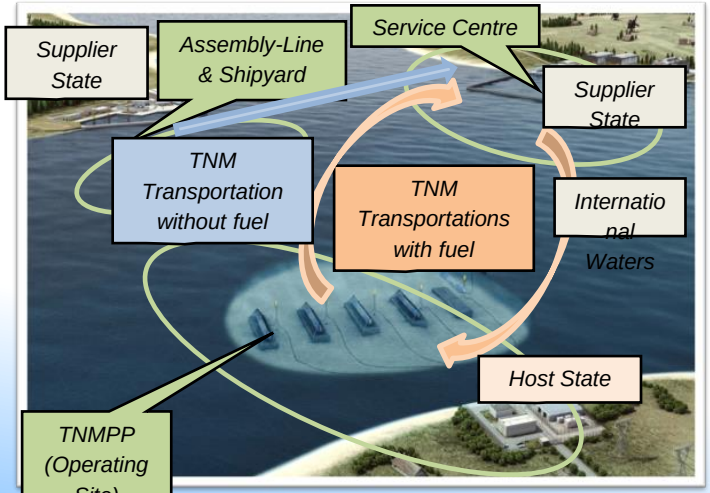
Collaborative Project: "INPRO Case study for the Deployment of a Factory Fuelled Small Modular Reactors (SMR)" – TNPP-2

- The 57th IAEA General Conference resolution encouraged "the Secretariat to continue providing guidance for regulatory reviews of SMRs of various designs".
- Collaborative Project was initiated by INPRO Steering Committee and started in 2015 and included integrated efforts of MSs and IAEA departments (NE, SG, NS and OLA)
- The overall objective of this Case Study is to examine, in detail, legal and institutional issues for export deployment of the particular type of TNPP with a factory fuelled, tested and sealed reactor and to investigate other aspects of transportable and modular reactor facilities: TNM (Transportable Nuclear Module) for deployment as TNMPP (Transportable Nuclear Modular Power Plant)
- The following Member States were involved in the particular tasks of the activity as participants or observers: Armenia, China, **France**, Finland, Indonesia, Romania, **Russian Federation** and **USA.**
- **History of Activities -** 2015-2023: 15 meetings (consultants' and ad-hoc)
  2023: additional internal review for publication as IAEA TECDOC

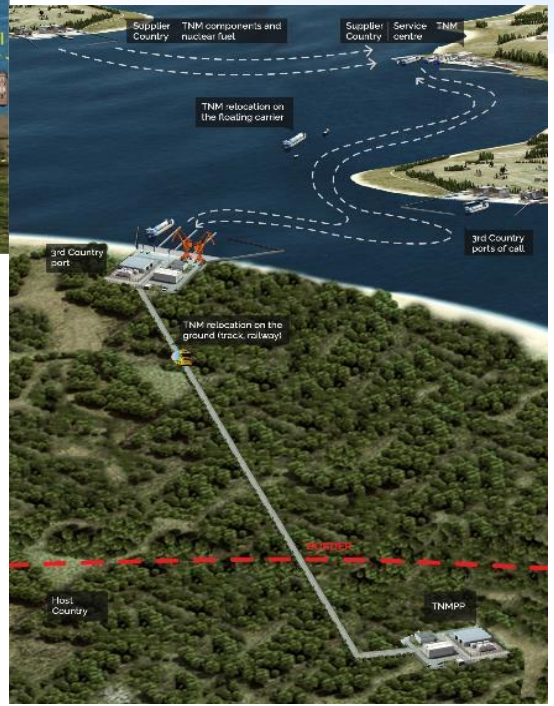
Three TNM/TNMPP cases



Floating TNM/TNMPP

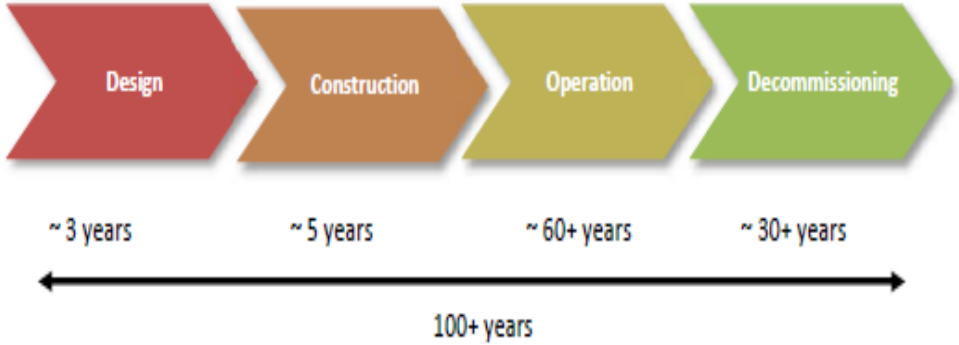


Submersible TNM/TNMPP

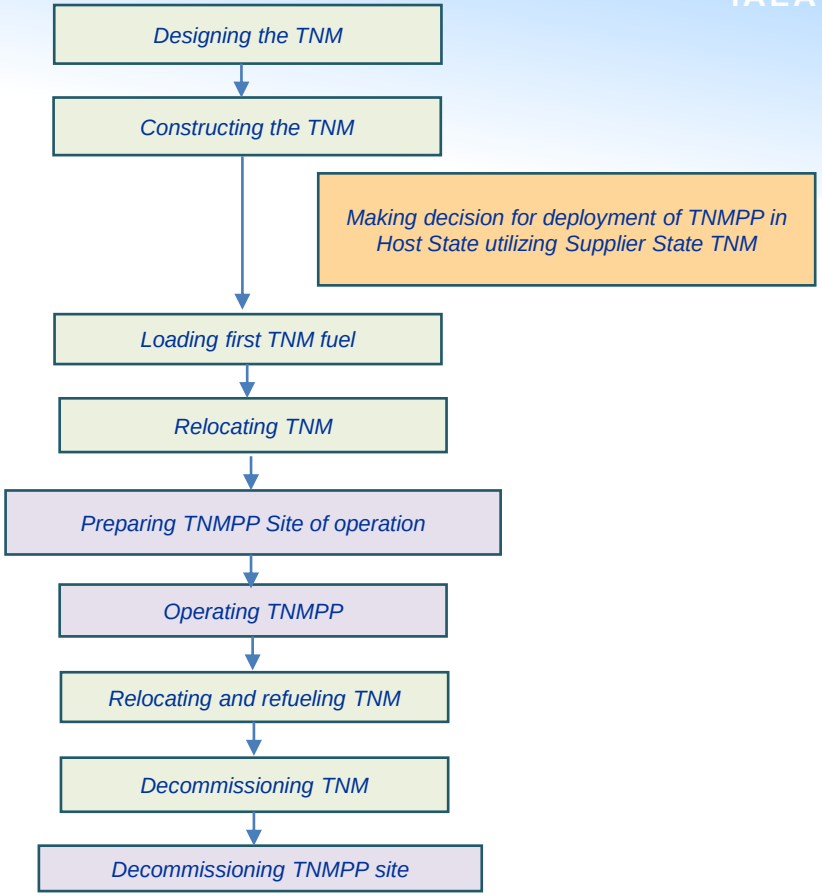


Land-based TNM/TNMPP

TNM/TNMPP Life-cycle



Traditional NPP life-cycle



TNPP-2 TECDOC

- The draft report based on the results of an in-depth study of the factory manufactured TNM life cycle scenario with reactors loaded with nuclear fuel in the Service Centre, tested and sealed in Supplier State for further relocation and operation as an integral part of a TNMPP in a Host State.
- For this study, a scenario was considered where the Supplier State is assumed to be a nuclear weapon State. The study included a scenario of maximum outsourcing as an illustrative example to demonstrate potential advantages of the design of TNMs that are factory manufactured, fuelled and sealed, and could be implemented in projects as integral parts of TNMPPs.
- The TECDOC draft includes the chapters:
  - Special issues relating to legislative (including Maritime Law and civil liability for nuclear damage)
  - Nuclear Safety Issues
  - Specific Issues relating to the Licensing Process
  - Special issues relating Safeguards
  - Nuclear Security Considerations
  - Specific Issues relating Staffing and Training

TNPP-2 Analysis: Identified gaps

Safety issues to be analysed: applicability of the system of international safety standards to factory fuelled SMRs; issues related to cooperation between the organizations of the Supplier State and the Host State and allocation of responsibility between them.

Licensing issues to be analysed: as licensing of factory fuelled transportable SMR may have differences from large land based reactors that are permanently installed in a fixed location the study is investigate some specific challenges.

Security issues to be analysed: application of existing recommendations on nuclear security to address the known concerns arising from the deployment of factory fuelled SMR.

Distributions and transitions of **responsibility between the Supplier and the Host States** during the implementation of the TNM/TNPP international life-cycle are suggested in the Case Study for:

- Civil liability for nuclear damage
- Licensing and nuclear safety
- Physical Protection
- Non-proliferation and safeguards
- Personnel carrying out the respective functions

TNPP-2 : from Conclusions on Special issues relating to legislative (including Maritime Law and civil liability for nuclear damage)

- I**nternational conventions on nuclear liability** could be applied and responsibility distribution between Supplier State and Host State should followed these Convention. Some specific points in area of Nuclear liability should be described in detail in IGA between the Supplier State and the Host State.
- Regarding maritime transport:
  - **TNM cannot be directly considered either as the transportation of nuclear fuel, or as the relocation of a nuclear ship with reactor(-s);**
  - It is necessary to suggest the Agency developing **harmonization with IMO** adopting, as far as possible, some special rules for application of current approaches to TNM relocations.
  - In the scenario of maximum outsourcing, the Supplier State should assume responsibility for all operations occurring outside the borders or territorial waters of the Host State.
  - The responsibility on TNMPP operation and safety belongs to the Host State's operating organization.
- The **greatest difficulty** in implementing the TNM/TNMPP concept may be **related to legal issues of TNM safe transportation** and special efforts of the IAEA should be devoted to this area.

TNPP-2 : From Conclusions on Nuclear Safety Issues

- Specific features of the **TNM/TNMPPs life cycle** implementation is expected to be performed **under the jurisdiction of two legal frameworks.** This requires cooperation between two national regulatory authorities.

- Having a flexible and generalized character of formulations, and without being bound to any engineering solutions and quantitative criteria, **the IAEA Safety Standards are considered to be applicable to TNMs and TNMPPs**

- **Conventions on nuclear safety and radiological protection have limited applicability** as TNM/TNMPP are frequently beyond their legal framework. Therefore, **specific nuclear safety requirements applicable to a TNM/TNMPP project and respective procedures should be defined for TNM/TNMPP designs** and should also take into account Host and Supplier State regulatory requirements.

Taking into consideration the specifics of a TNM/TNMPP life cycle, the following may be required:

- Revised and additional requirements and guides for site assessment for floating and submerged TNMs;
- Revised and additional recommendations and guides for a graded approach application for TNM *and its transportation*;
- Development of innovative approaches (alternative to those adopted for conventional plants) for periodic confirmation of nuclear safety during TNM/TNMPP operation.

TNPP-2 : From Conclusions on Nuclear Security

The basis for the implementation of physical protection for a TNM/TNMPP rests on the well-recognized **basic principle of nuclear security.**

- **The application of the existing A/CPPNM and the IAEA recommendations would appear sufficient to address the concerns arising from the deployment of a TNM/TNMPP.**
- The complexity of access to the fuel in a sealed TNM effectively **minimizes unauthorized removal of nuclear material as a threat.**
- **Transit of radioactive nuclear material** between States has long been dealt with and precedents are well established.
- Inclusion of **security by design elements** may play an important role in implementation of requirements for detection, delay, and response during operation.
- A TNMPP, like some SMRs, may have a **limited physical footprint which will reduce available standoff distance and response time for the physical protection system**.
- Taking into consideration all the above, it appears that an **effective physical protection approach could be developed for a TNM/TNMPP during all stages** of its life cycle based on existing international documents, while additional documents may provide valuable technical guidance.

TNPP-2 : From Conclusions on Specific Issues relating Safeguards

IAEA safeguards should be applied **under the Host State's CSA while the TNM is at its Operating Site** as part of the TNMPP, located in the territory of the Host State. The Supplier State should facilitate, under its VOA (Voluntary offer agreement) and/or through other agreements with the Host State and possibly the IAEA.

- Any relocations back to the Supplier State Service Centre for defuelling/refuelling and maintenance should include activities described after receipt by the Service Centre.
- The Supplier State may consider incorporating certain safeguards-related features into the design of the TNM/TNMPP.
- **The IAEA should receive, examine, and verify the design information** sufficiently in advance for it to develop an effective and efficient IAEA safeguards approach.
- Legal instruments and perhaps other arrangements are necessary to establish the basis for the Supplier State to transfer TNM/TNMPP design information to the Host State.

The principal **verification activities by IAEA inspectors in the Host State are considered.**

TNPP-2 Case Study Conclusions

1. **Existing legal and regulatory framework** for NPP is generally applicable to TNM/ TNMPP life cycle. May require modifications for safeguards, nuclear damage civil liability, etc.
2. Differences in regulatory framework compared to NPPs is **marine specifics of a TNM** (floating and submersible designs,) and maritime laws regarding transport of TNM/TNMPP between Supplier State and Host State. May need innovative licensing mechanisms.
3. Identified "gaps" in legal framework of TNM/TNMPP for current technology development stage, may be covered by **Intergovernmental Agreements** for the implementation of particular TNMPP projects.
4. **TNM Pilot Projects (FOAK)** will bring new practical information for further deployment of TNM/TNMPP.

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Thank you for attention!

*And **special thanks** to all contributors, reviewers and participants of INPRO TNPP-2 Case Study*

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https://www.iaea.org/services/key-programmes/international-project-on-innovative-nuclear-reactors-and-fuel-cycles-inpro