International Project on
Innovative Nuclear Reactors and Fuel Cycles
(INPRO Section)

Terms of Reference

INPRO Collaborative Project

"Case Study for the Deployment of a Factory Fuelled SMR"

CONTENT

SCOPE OF THE WORK

for the INPRO Collaborative Project

"CASE STUDY FOR DEPLOYMENT OF FACTORY FUELLED[1] SMALL MODULAR REACTOR"

1. Introduction

The International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) was established in 2000 — as an IAEA flagship project, through a General Conference resolution — with the goal of ensuring a sustainable nuclear energy supply to help meet 21st century global energy needs.

INPRO's activities are centered on the key concepts of global nuclear energy sustainability and the development of long-range nuclear energy strategies, so that nuclear energy is and remains available to meet national energy needs.

There is renewed interest in Member States in the development and application of Small and Medium/ Modular Reactors (SMR). They have potential to allow countries with smaller grids and lower economic means to develop nuclear power and reduce their carbon dependence, ensuring sustainable development. SMRs are an efficient path for innovation in design, technologies, safety, security and safeguards, and even industrialization, industrial organization or business models.

One of the INPRO activities investigated the legal and institutional aspects of Transportable Nuclear Power Plants (TNPP) which are a subset of SMRs and are expected to be factory manufactured (assembly line), fuelled and sealed prior to transport to a site. The focus of this activity was on TNPP deployments in countries other than the country of origin. A transportable nuclear power plant is defined as a factory-manufactured, transportable and/or re-locatable nuclear power plant, which, when fuelled is capable of producing final energy products like electricity, process heat, etc. The TNPP is physically transportable, but is not designed to either produce energy during transportation or provide energy for the transportation itself. Initially these designs are expected to be small, with an output of less than 300 MWe per unit because it is likely unrealistic to transport larger units.

When such reactors are fuelled and tested at the factory, their export deployment may face specific issues in the international context related to the compliance with international legal norms and the IAEA safety standards and security recommendations in the periods of fuelled reactor transportation.

A TNPP can be defined as a Transportable (Marine Immersed or Surface or Land-based) Nuclear Power System encompassing at least two sites (a production site / a supporting site) with a transportable reactor unit conveyed between them. The system described is not designed to either produce energy during transportation or provide energy for the transportation itself.

Unlike conventional land based nuclear plants or site refueled land-based SMRs which require a systematic on-site construction, the transportable reactor unit is fully modular and completely produced in an assembly line by a Supplier, tested and then transported to the production site for operation.

[1] A "Factory Fuelled SMR" in this project means a TNPP (and associated nuclear systems) that is fuelled and sealed prior to shipment and no refuelling is performed at the site where the plant is deployed.

A preliminary study addressing the specific regulatory challenges of the Transportable SMRs (Transportable Nuclear Power Plant: TNPP) was performed in 2008-2013. It resulted in the Nuclear Energy Series Technical Report No. NG-T-3.5.

The 57th IAEA General Conference resolution (GC(57)/RES/12) encouraged "the Secretariat to continue providing guidance for regulatory reviews of SMRs of various designs". One type of SMR is Transportable nuclear power plants (TNPP). TNPP introduce a new paradigm of nuclear implementation, intrinsically reinforcing international cooperation. Those plants are assembled from factory-made transportable modules on a dedicated site: it includes SMRs with integral operating lifecycle implemented on a single platform (transportable nuclear power plants). In considering TNPP industrial fabrication and mobility conditions, the IAEA has defined its capacity up to 300 MWe.

The 22nd Steering Committee of the INPRO (24-27 June 2014) agreed to restart activity on TNPP II under a new name. The collaborative project "Case Study for Deployment of Factory Fuelled SMR" is based on information mentioned above. It will be implemented as Activity 2.3 under Task 2 "Innovations" of INPRO Action Plan 2014–2015, from July 2014.

2. Rationale

Among the SMRs, introducing a TNPP may require less financial and human resources from the Host State, in comparison with any other Land Based SMRs (LB-SMRs) or Large Land Based Reactors (LLBRs). However, there are a number of issues to be considered either related to the manufacturing, operation or transportation between sites. Those issues have to be foreseen in light of the major players which should be defined, associated with the different sites and moveable equipment.

The Nuclear Energy Series Technical Report No. NG-T-3.5 mentions that when factory fuelled and tested reactors are to be used, there are obvious gaps and insufficient coverage of certain related activities in the international nuclear law and related regulations, as well as in the non-binding international norms – IAEA safety standards.

3. Overall Objectives

The INPRO Collaborative Project "Case Study for Deployment of Factory Fuelled SMR", is tasked with examining, in detail, legal and institutional issues for export deployment of a TNPP with a factory fuelled and tested reactor and to investigate other aspects of transportable and modular reactor facilities.

Key Deliverable:

The INPRO Collaborative Project "Case Study for Deployment of Factory Fuelled SMR" will develop and publish a report composed of two parts. The report will:

- Disseminate information to decision-makers and the public and
- Provide enough information that nuclear experts can use to further explore and resolve the issues raised

The report will discuss proposes scheme(s) of possible deployment and related activities to assist newcomers or countries with developed nuclear energy systems for implementation and use of Factory Fuelled SMR:

- PART 1: A high level life cycle narrative (including illustrations) encompassing 3 life-cycle but technology neutral SMR export "stories" and comparisons between them where possible:

  This narrative is oriented towards decision-makers and, as a result, should be written in plain language.

- PART 2: For each phase of the above narratives, more detailed sections can be written to expand on issues and possible solutions.

The report will cover issues arising from implementation of:

- Applicable International Treaties, Conventions and standards. (e.g. Non-Proliferation Treaty, Convention on Nuclear Safety, International Maritime Organization (IMO) Conventions)
- nuclear safeguards & non-proliferation activities,
- nuclear safety & security, environment, emergency management including obligations and responsibilities
- measures to assign liability for consequences of nuclear accidents and how those liabilities are transferred between responsible parties

This effort will identify, when noted, issues with application of IAEA safety standards to SMRs; however, it will not conduct a detailed review of IAEA documents to identify gaps.

4. Specific Objectives & Assumptions

The report will cover three case studies and will seek to understand similarities and differences among them.

Case Study I: Factory Fuelled & Sealed Sub-surface Marine Based SMR

Case Study M: Factory Fuelled & Sealed Surface Marine Based SMR

Case Study L: Factory Fuelled & Sealed Land Based SMR

Assumptions Used In the Case Studies:

To achieve this objective, the Project has adopted the following assumptions as a starting point to ensure case studies are roughly similar:

- Capacity to build and operate the manufacturing and service facilities already exists
- Capacity to operate the facilities will be demonstrated by the operators prior to initial deployment to site
- Service facility country regulator is capable of regulating activities around assembly and testing

- Host country regulator is inexperienced with this technology
- The Service Facility is in a different country from the host state
    - Need to discuss assumptions about agreements between both parties
    - The Service Facility is to be considered the point at which the reactor is fuelled, sealed, tested, and readied for transport. Testing prior to shipment will include (as a minimum) low power nuclear operation.
- Returning units are either refurbished or decommissioned at the Service Facility.
- For the marine based cases Spent fuel and waste will be stored and managed at the Service Facility pending disposition
- For Land-Based Case: Spent fuel and waste will consider two cases: storage and management in the Host Country (disposable module) or repatriation to the Service Facility's country (reusable or disposable module), in each case, pending disposition
- The service facility will service multiple sites from multiple states
    - The service facility is in the vendor country
    - To discuss issues around inventories of new and spent fuel (inspection)
    - Safety inspections
- The vendor country is a non-full-scope safeguards state, the host country is a full scope safeguards state (conservative scenario)
- The transporter (carrier) is a separate entity (3rd party) from the service facility and the host country operator
    - Discuss handover points re assumption of risks and liabilities – turnover of plant from service facility to/from carrier
    - What requirements does the carrier (owner & crew as separate entities) need to follow? (vendor state, host state, laws of the sea?)
- The transport route will transit through one or more 3rd countries' territories (and may also transit international waters)
- The operation site in Host Country - Operator at the site is different company from the service facility (this will introduce responsibility conflicts)
        - Discuss handover points re assumption of risks and liabilities – turnover of plant from service facility to/from operator

5. Scope of the Work

The report is composed of two parts:

- PART 1: A high level life cycle narrative (including illustrations) encompassing 3 life-cycle but technology neutral SMR export "stories" and comparisons between them where possible:

  This narrative is oriented towards decision-makers and, as a result, should be written in plain language. The team has decided that it cannot discuss economic considerations in this report without significant details about each specific case. Economic discussions would also require specific set of skills be brought into the project.

  Initially the team will document three separate narratives as follows:

- Reference case for report - Factory fuelled sub-surface marine-based SMR – (Flexblue as the reference type behind the discussions)
- Surface (floating) marine-based SMRs, – (Barge Mounted KLT40S as the reference type behind the discussion –service facility fuelled reactor only)
- A small land based factory fuelled transportable SMR. – (UNITHERM as the reference type) – site infrastructure (i.e. balance of plant) is fixed, but reactor moves

The team is of the opinion that the three case studies may prove to be very similar in execution. As a result, using the results from the three narratives, the team will identify areas of similarities and highlight differences to see whether the narrative can be combined into a single narrative with only the differences highlighted for the other two.

- PART 2: For each phase of the above narratives, more detailed sections will be written to expand on issues and possible solutions. A suggested (but not exhaustive) list of subject to be discussed <u>in each step</u> of the Case Study narrative is provided below:

  - Identifying necessary host country interactions with the service facility country
  - <u>Who</u> is liable <u>when</u> and how is liability transferred between parties (talk about who assumes risks as fuel changes hands) Including accidents and malfunctions at site, service facility and in transit
    - Clarify in the document who needs to be part of the discussions (role of site operator, transport company and service facility)
    - Identify key points at which transfer occurs and what types of documentation are needed
    - 3rd party shipments?
  - Physical protection at site, service facility and in transit –including characterizing Design Basis Threat (DBT) (generally prescribed by the regulatory jurisdiction governing security)
    - Discuss the role of integrating physical design features into the facility
    - Discuss any particular risks posed by (sub)marine siting
    - Establishing different security protection areas under different national security jurisdictions
  - Application of IAEA safeguards:
    - Authority to receive and verify design information and material inventory in the Service facility state
    - Ability to receive and verify design information and material inventory in the Host state
    - New technologies (e.g. satellite imaging) could be helpful / needed
    - New policies (e.g. reduce reliance on reverification) could be necessary
  - safety regulation of components may vary (Codes and standards used may vary depending on the Host State)
  - hypothetical licensing steps for the service facility, transport and the site including regulatory and operator interactions & responsibilities. Include discussions about:
    - Access by regulatory bodies (may be more than one) for inspections
    - Access by operators for inspections

- Transportation – Characterizing routine transfers, accidents and malfunctions – Is the current transportation legal framework adequate for these? Emergency planning – issues and measures to be considered during transport between the Service Facility country and the Host Country
- Identify which conventions and treaties need to be applied and how they impact potential deployment (e.g. International Maritime Organization (IMO), Convention on Nuclear Safety etc.)
- Challenges to regulatory bodies who are seeking to share information in assessment of safety cases
- Challenges in training SMR operating and maintenance personnel for deployment in different jurisdictions

6. Expected outputs

To:

- Disseminate information to decision-makers and the public and
- Provide enough information that nuclear experts can use to further explore and resolve the issues raised

A visual representation and description (in plain English) of the three deployment case studies from "cradle to grave" in order to facilitate the following results:

- An understanding of the key legal and regulatory issues (gaps) that will need to be resolved between the vendor country, the host country and third party countries along the transport route.
- To identify possible solutions that can be realistically pursued (in near future) to resolve the above issues
- To recommend further activities to be pursued by the IAEA

Included in the above should be discussions about:

- the transactions that must occur in order to transfer liability between parties involved in the deployment of factory fuelled
- the minimum level of interaction needed between the host state operator / regulator and the supplying state regulator / service facility
- whether additional requirements/guidance are needed under the IAEA framework (safety standards, safeguards, security publications)
- whether any additional legally binding agreements are needed between the involved states