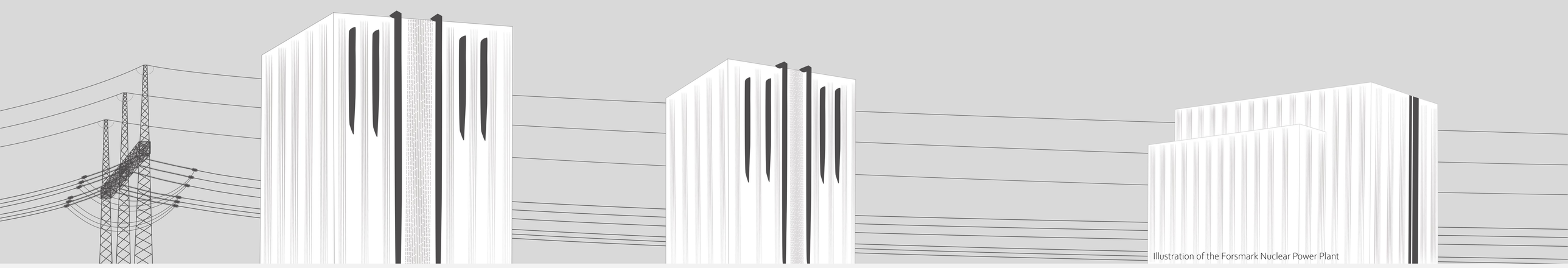

Proliferation resistance assessment using the INPRO methodology

Introducing light-water SMRs in Sweden

Claudia Olaru · Erik Branger · Sophie Grape

Department of Physics and Astronomy, Uppsala University, Sweden
Contact: claudia.olaru@physics.uu.se

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Introduction

ANItA project

Swedish competence center
Scope:

- Bring together academia & industry
- Study on deploying SMRs in Sweden
- Construct competence on SMRs
- Build a sustainable energy future

Our work package

Study SMR deployment in Sweden:
- logistical, legislative, technical aspects
- non-proliferation challenges
- nuclear safeguards verification solutions

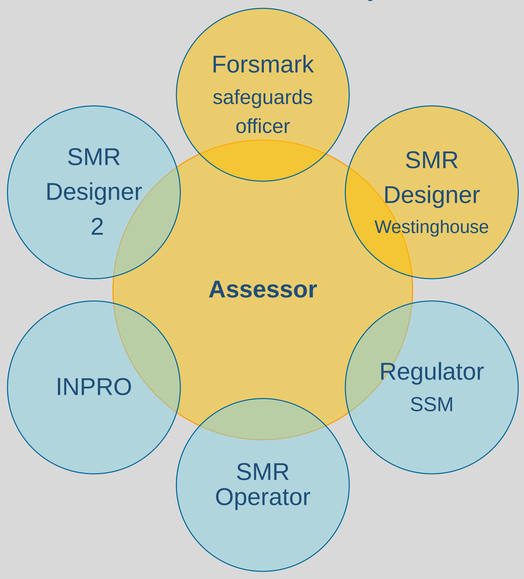
In this work

A. Beginning of a proliferation resistance (PR) assessment
B. Defined SMR deployment scenario
C. Outcome of the work

A. Applying the INPRO methodology
steps taken for a PR assessment

1) Forming an advisory team
2) Studying the INPRO PR Manual + 2023 draft version
3) Observing the INPRO Steering Commitee Meeting
4) Discussion with SMR designer representatives
5) Discussion with the safeguards officers at Forsmark
6) Discussion with former SSM employee on the non-proliferation Swedish legal framework

Members of the advisory team



Legend: yellow – team member, blue – representatives are welcomed!

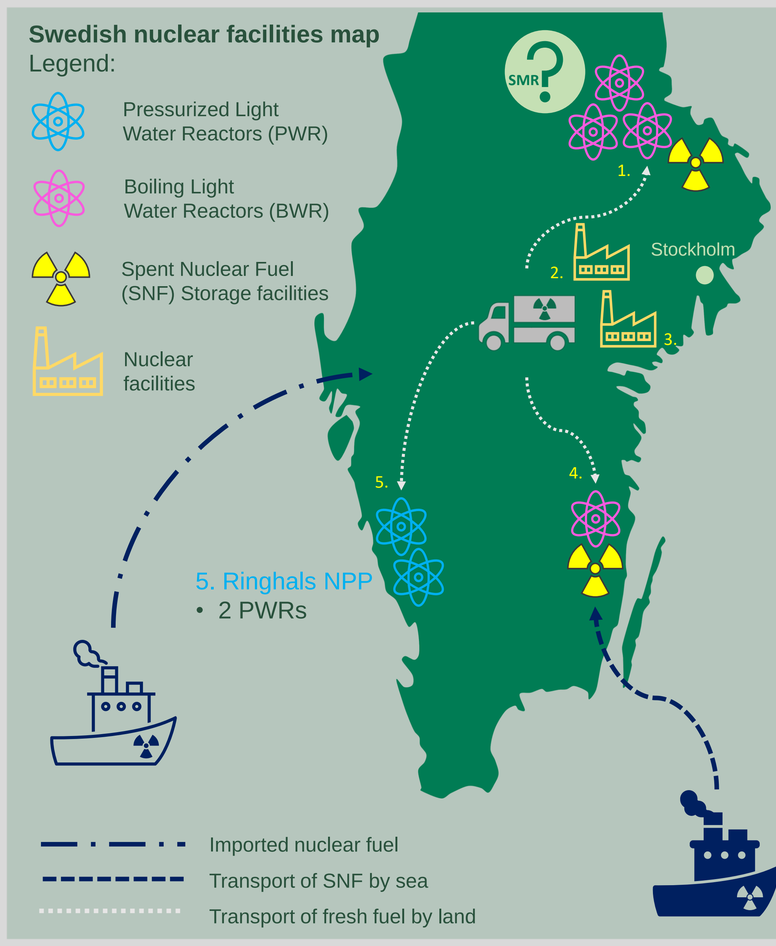
Open Questions

? Should the assessment include the plutonium content in the SNF, given Sweden's focus on an open fuel cycle

? What should be the level of including private nuclear technology companies in the assessment

? What aspects of other sustainability areas (e.g., economy, safety, waste management) could immediately influence proliferation resistance

B. SMR deployment scenario
extending the Swedish nuclear power programme



1. Forsmark NPP site
- 3 BWRs
- SNF geological repository (*planning and licensing stage*)

2. Nuclear fuel factory
- Fuel from imported raw nuclear material
- Transport of fresh fuel by truck

3. Studsvik
- Fuel & material testing
- Waste management and storage

4. Oskarshamn NPP
- 1 BWR
- Central Interim SNF storage facility (Clab)

- Transport of SNF from NPPs to Clab is done only by ship

Scenario specifications

- Location
  Forsmark NPP - existing nuclear site
- Location assets
  personnel expertise, grid connection, harbour
- Usage
  electricity production with **load-following**
- Design

  AP300™ SMR
  Westinghouse Electric Company LLC
  → type: pressurized light-water modular reactor
  → fuel type: low-enriched UO_2 with IE < 5 %
  → fuel assembly length / array: 12 feet / 17×17 rods
  → refuelling cycle: 36 months (flexible to 21 or 48)
  → estimated thermal / electrical capacity: 1000 MW_t / 330 MW_e
- Number of units
  3 x AP300, that would have a total electrical power output close to a large-scale reactor

C. Outcomes
preliminary results of the PR assessment

UR	Description	Criteria	Comments
1	Sweden's non-proliferation obligations and commitments	**CR1.1 (met)** legal framework	+ EU regulations covering nuclear safeguards & export control + National legislation that implements the non-proliferation regime
		CR1.2 institutional, structural arrangements	– ISSAS Mission never requested + Regulatory authority is operational and independent, and SSAC is established – Very limited interaction with the regulatory authority on performing the assessment + Several bilateral cooperation agreements, international dependency on nuclear material and technology, multi-national/–lateral ownership of nuclear facilities
2	Low attractiveness of nuclear technology and materials within NES	**CR2.1 (met)** nuclear technology	+ Hot cells and fabrication of uranium oxide fuel are available, but for private companies + Other technology mentioned under UR2 is not available + No state-owned companies that produce nuclear or dual-use technology
		CR2.2 nuclear material	+ SMR design employs the same type of nuclear material as the one currently used, so the attractiveness of the material would not be increased – Quantity of fresh fuel not assessed – Plutonium content in SNF not assessed
3	Facilitation of IAEA Safeguards via intrinsic and extrinsic features / measures	**CR3.1** / CR3.2 - effective / efficient safeguards implementation	– No available plant layout on the AP300 SMR design - diversion pathway analysis cannot be performed by the assessor, cannot answer design-related questions – Questions under CR3.2 are oriented towards facility design – not assessed for AP300 + Designer was informed about existing safeguardability analysis methodologies [1], which could be employed to determine if the SMR design requires more effort for its safeguards verification than a comparable facility under the same safeguards regime + Assessor studied the application of safeguards at the Forsmark NPP to reason how current measures applied for large-scale reactors and personnel experience could enhance PR in deploying SMRs + **CR3.1** is met in the case of the Forsmark NPP

[1] BARI, R. et al., "Overview of the Facility Safeguardability Analysis (FSA) Process", PNNL-21698 (2012)

Conclusions

- Sweden focuses on an open nuclear fuel cycle – licensing final geological repository in progress
- Applying the INPRO methodology is a long process that requires interaction with various actors
- Limited interaction with regulator and no SMR layout information affects the progress of analysis
- Work will continue on assessing if all User Requirements (including UR4 and UR5) are fully met
- Assessment will further include the front end, back end, and decommissioning aspects of NES
- There is an interest to consider other SMR designs in the analysis, with available layout details
- Based on the final assessment results, a set of guidelines will be developed for the stakeholders

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