

Illustration of the Forsmark Nuclear Power Plant

Integration of Small Modular Reactors in the Swedish Nuclear Energy System: A Proliferation Resistance Study

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Introduction



In this work

- A. Steps for a proliferation resistance (PR) assessment using INPRO methodology
- B. Defined SMR deployment scenario
- C. Outcome of the work

ANitA - Swedish competence center

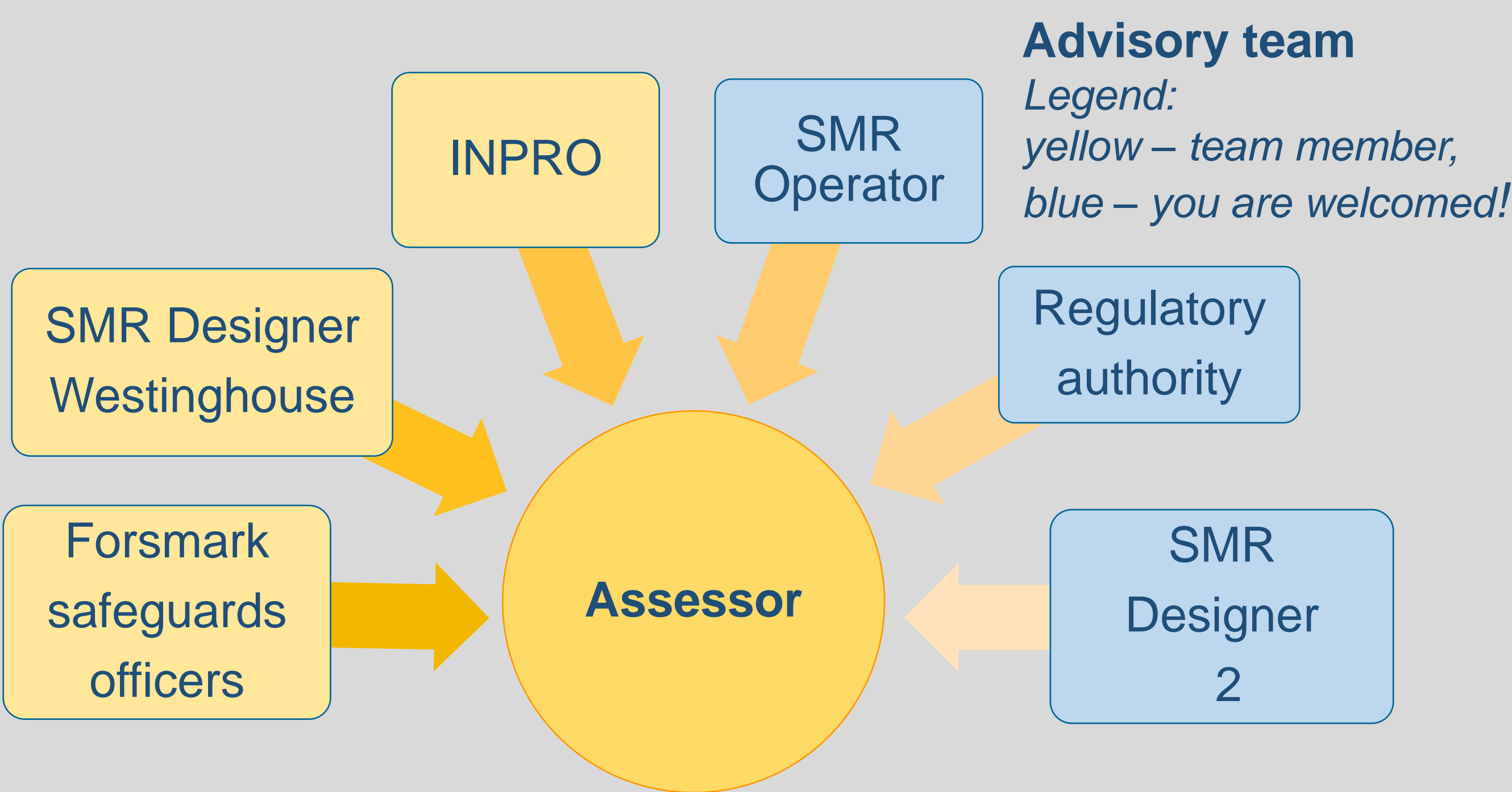
- Bring together academia & industry
- Study on deploying SMRs in Sweden
- Construct competence on SMRs
- Build a sustainable energy future

Our project

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

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

- 1) Forming an advisory team
- 2) Studying the INPRO Manual on Proliferation Resistance
 - draft publication from 2023
- 3) Meeting with SMR designer representatives
- 4) Meeting with the safeguards officers at Forsmark NPP
 - previous expertise on implementing safeguards
- 5) Meeting with former employee of the national regulator
 - overview of the Swedish legal framework on non-proliferation



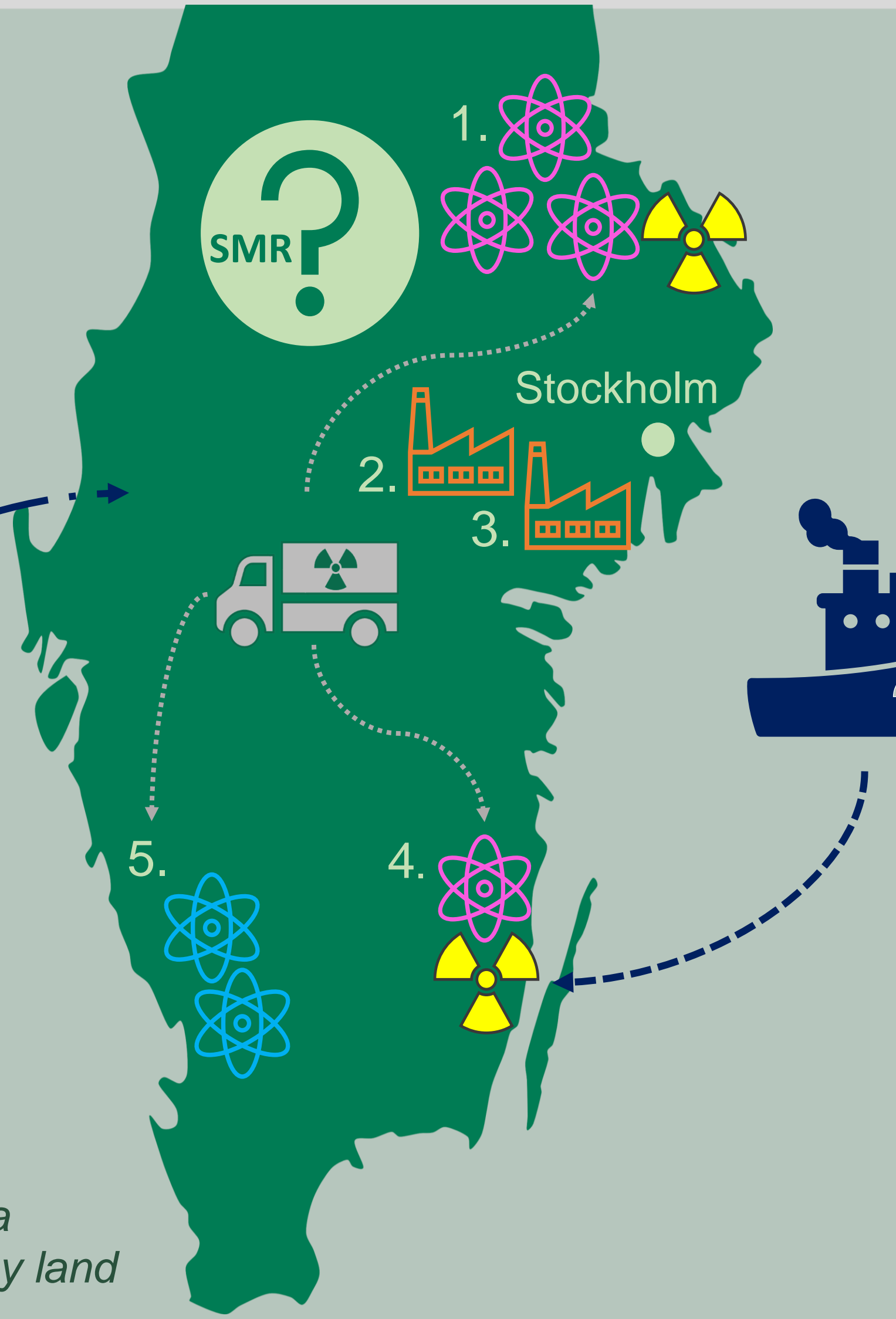
B. SMR deployment scenario: extending the Swedish nuclear power programme

Swedish nuclear facilities map

Legend:

- Pressurized Light Water Reactors (PWR)
- Boiling Light Water Reactors (BWR)
- Spent Nuclear Fuel (SNF) Storage facilities
- Nuclear facilities

--- Imported nuclear fuel
--- Transport of SNF by sea
--- Transport of fresh fuel by land



- 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

- 5. Ringhals NPP**
- 2 PWRs
 - Vattenfall's SMR feasibility study at Ringhals

Transport of SNF from NPPs to Clab is done only by ship (Sigrid)

Scenario specifications

- Location – existing nuclear site, **Forsmark NPP**
- Location assets – personnel expertise, grid connection, harbor
- Usage – **electricity production with load-following**
- Design – **AP300™ SMR** Westinghouse Electric Company LLC
- Number of units – **3**, total electrical power output close to 1 large-scale unit

C. Outcomes: preliminary results of the PR assessment

Criteria	Comments
CR1.1 / CR1.2 proper legal framework / suitable implementation	+ National legislation and EU regulations implement the non-proliferation regime + SSAC (State's System of Accounting and Control) is established – IAEA SSAC Advisory Service mission never requested + International cooperation and dependency on nuclear material and technology
CR2.1 / CR2.2 nuclear technology / nuclear material attractiveness is acceptable	– Hot cells, fabrication of uranium oxide fuel are available, + but for private companies + No state-owned companies that produce nuclear or dual-use technology – Quantity of fresh fuel and SNF not yet assessed; further study needed + SMR design employs the same type of fresh nuclear fuel as the one currently used
CR3.1 / CR3.2 effective / efficient facilitation of IAEA nuclear safeguards	+ Forsmark NPP meets CR3.1 through effective and detailed safeguards procedures + Procedures like nuclear material accounting, handling outages and damaged fuel, enhance proliferation resistance, and could be employed for SMRs – No information available yet on the AP300 plant layout / diversion pathway analysis – SNF from SMRs might require dedicated new storage solutions like dry storage

Conclusions

- Sweden adopts an open nuclear fuel cycle
- SMR integration scenario is outlined
- INPRO assessment findings:
 - ✓ Legal framework aligns with international standards
 - ✓ International dependency on nuclear material and technology enhances PR
 - ✓ Forsmark safeguards system is effective and adaptable to SMRs
 - ✓ Spent fuel from SMRs poses potential challenges, which could be solved through safeguards-by-design

Acknowledgments

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