The Potential Impacts of SMRs on Multinational Cooperation at the Back-end of the Fuel Cycle

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SMRs: Key Questions

- Are they a “game changer” for the future of nuclear power?

SMRs: a big game changer?

Could small modular reactors be a game changer in nuclear energy’s contribution to tackling climate change? **Charles McCombie, Robert Budnitz, Noura Mansouri, H-Holger Rogner, Robert Schock** and **Adnan Shihab-Eldin** examine the market, barriers to deployment and what is needed to overcome them

- Are the potential advantages proven?
  - *Safety, Cost, Financing, Implementation Times…*
- How might they affect back-end challenges?
  - *The “waste disposal problem”…*

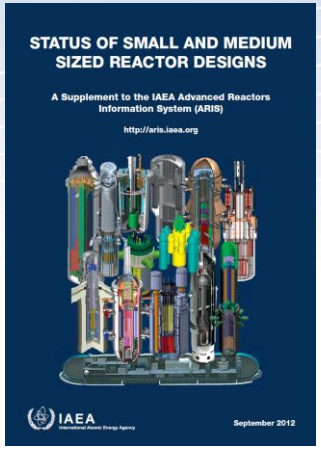
International SMR Projects

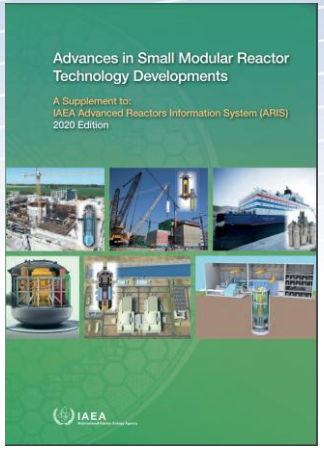
- **European SMR pre-Partnership**
  - Organised by the EC's DG ENER in response to European nuclear industry
  - 110 participants from 22 Member States: *WS1 Market analysis, WS2 Licencing, WS3 Financing, WS4 Supply chain adaptation*

- **IAEA - intensive activities related to SMRs**
  - 'SCORPION' Platform on SMRs and their applications*: SMR Coordination and Resource Portal for Information Exchange, Outreach and Networking*
  - New TC Interregional Project: *Supporting Member States' Capacity Building on SMRs/Microreactors, their Technology & Applications (2022 – 2025)*
  - SMR Regulators' Forum
  - Technical Working Group for Small/Medium/Modular Reactors (TWG SMR)

Why do we need another project?

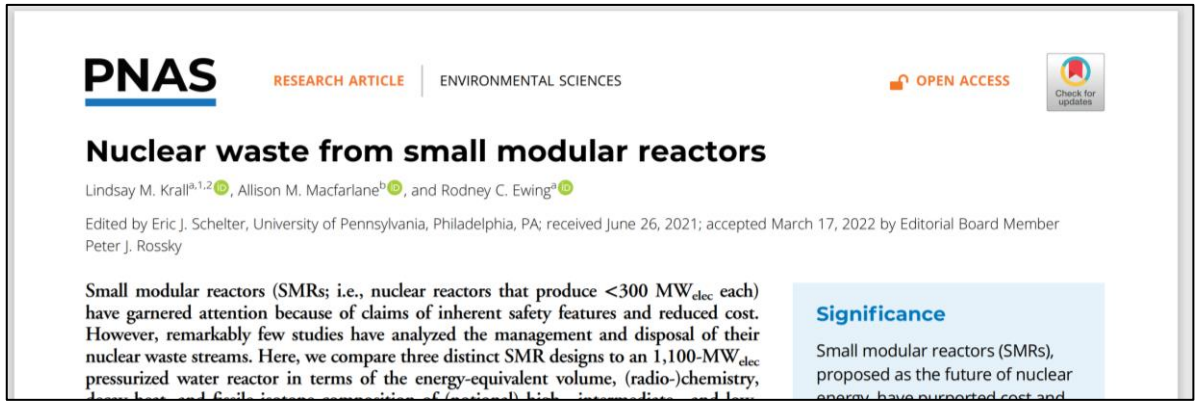
- **Significant focus on SMR technologies, use cases, reactor design, fuels…**





…but relatively little work has been done on the back-end impact.

- The most recent work has been of a technical nature and caused some controversy:



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Nuclear waste from small modular reactors

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Small modular reactors (SMRs; i.e., nuclear reactors that produce <300 MW_{elec} each) have garnered attention because of claims of inherent safety features and reduced cost. However, remarkably few studies have analyzed the management and disposal of their nuclear waste streams. Here, we compare three distinct SMR designs to an 1,100-MW_{elec} pressurized water reactor in terms of the energy-equivalent volume, (radio-)chemistry,

Significance

Small modular reactors (SMRs), proposed as the future of nuclear

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USDOE-ERDO SMR Project Drivers

- Acceptance of nuclear is/has been strongly affected by disposal issues:
  - ERDO focuses on where/how/when multinational cooperation could ease back-end challenges
  - USDOE International Programme has long supported multinational cooperation (INPRO, IFNEC, Study on Jordan Dual Track Policy, Arius, ERDO)

- Therefore...

…this new project focuses on the potential impacts of SMRs on multinational cooperation at the back-end of the fuel cycle.

USDOE-ERDO Project Phase 1: Technical Issues

1. **SMR technologies & suppliers**
   - Focusing on current / near-future SMR technologies, based on options being investigated and/or financed by governments & private organisations
2. **SMR fuel characteristics**
   - High-Evaluation of characteristics of spent fuel produced by those SMR technologies and comparison with existing spent fuel inventories
3. **SMR fuel disposability**
   - Comparison of SMR fuel characteristics relevant to disposability
4. **SMR operational and decommissioning wastes**
   - Scoping assessment of the types & amounts of wastes generated over SMR lifetimes and comparison with existing waste streams/inventories
5. **SMR impact on management of a national nuclear fleet**
   - Consideration of impact of SMR insertion into nuclear power programmes (both established & 'new nuclear' nations) on overall technical planning for radioactive waste management

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USDOE-ERDO Project Phase 2: Strategic Issues

1. **Strategic aspects of the international SMR market**
   - Evaluation of potential supply and demand landscape, covering SMR technologies and fuel cycle impacts/solutions – e.g., reprocessing, waste ownership, SMR supplier 'take-back'
2. **Costs of SMR fuel waste management**
   - Preliminary evaluation of the likely cost implications of disposal of SMR fuels (considering a wide range of disposal options/concepts/scales and consideration of logistics & transport)
3. **Impact of SMRs on MNR planning:**
   - Assessment of SMR concept/design, economics and scheduling impact on a shared / commercial MNR project if a number of users were to require disposal of SMR fuels and wastes

- **Stage 2 should highlight key international policy considerations for USA & ERDO nations and should point towards opportunities for harmonization of approaches to SMR fuel management.**

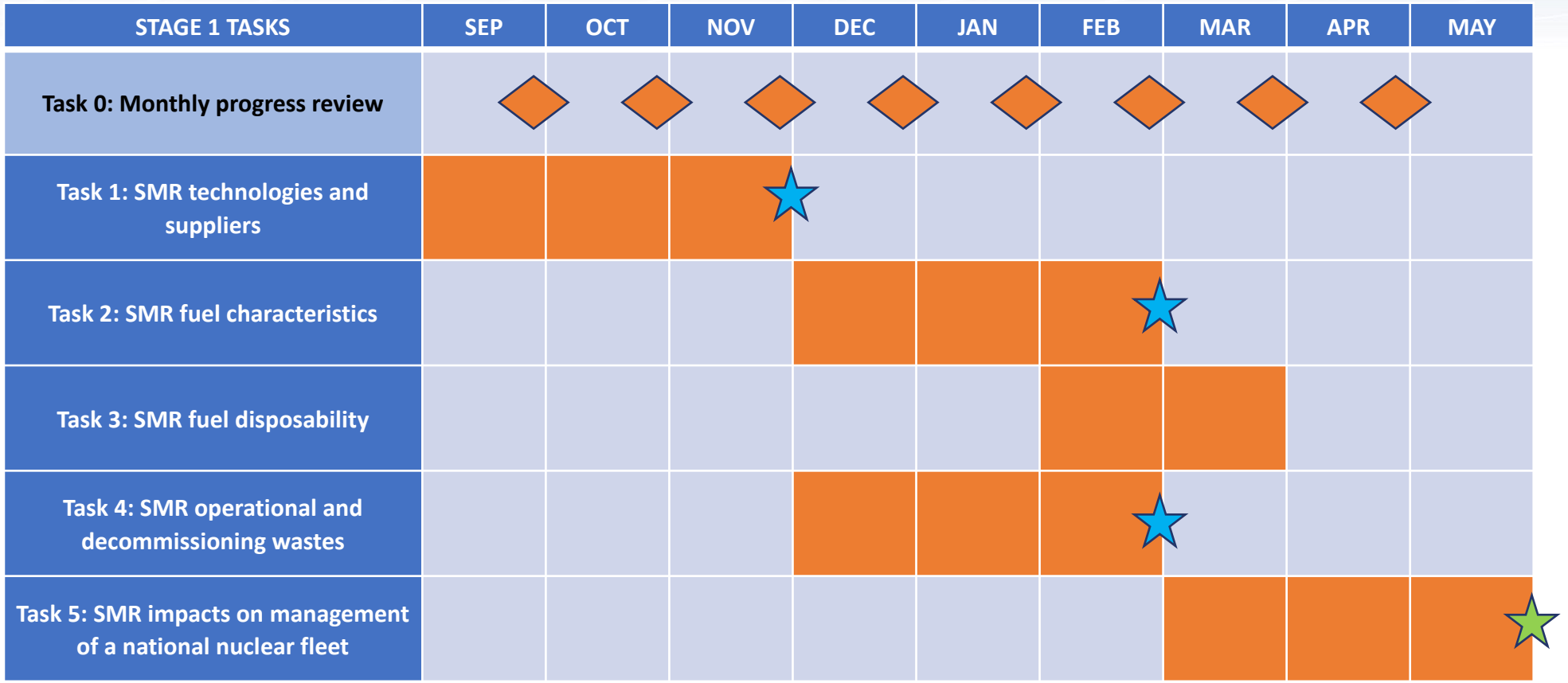
Phase 1 Programme

Project Start

Informal Deliverable / Progress Reporting

Informal Deliverable / Progress Reporting

Formal Deliverable
- Fully QA'd written report suitable for peer review and publication
- Outputs from other Stage 1 Tasks incorporated as appendices.



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Potential Impacts of 'Take Back' on Widespread Adoption

SMR suppliers *may* work with nations to offer a 'take back' of SF / entire modules

- 'Take back' would be particularly beneficial to countries considering nuclear
- If the "waste disposal problem" is removed by a 'take-back' offer, even non-nuclear countries may reconsider
- Existing nuclear countries with small programs would benefit from a 'take back' option if SF from existing plant(s) could also be exported
- Pressure by multiple customers may make 'take-back' of SF more likely

Potential Impacts of Multiple Customers

- Renewed interest in the ‘commercial service provider’ approach for a repository – led by a SMR producer country, a user country or even a non-nuclear country
- Security issues of wider nuclear uptake (numerous countries with 1 or more SMR) may strengthen international support for implementation of a large, secure MNR
- Multiple customers for the same SMR design may cooperate on approaches to SF conditioning & packaging development
- SMR suppliers – especially those with novel fuel cycles – may be interested in building multinational “user groups”

Potential Impacts on ‘Nuclear Country’ Policy

- Existing nuclear countries may complement their fleets by introducing distributed SMRs fulfilling various functions (process heat, district heating, etc.)
- SMRs may enhance the “image” and the acceptability of nuclear power so that large NPPs also become more acceptable
- Major established disposal programmes may see opportunities in accepting relatively modest amounts of SF from new SMR countries

Conclusions

- Enthusiasm for SMRs is high & global in existing & ‘new nuclear’ countries
- Many of the potential advantages have yet to be demonstrated
- Impacts on SF management and disposal are barely explored
- Concentrating SF management and disposal at fewer sites can improve safety, security and economics
- The established drivers for MNRs are becoming stronger

Thanks – Any Questions?