IAEA Activities on SMRs

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Nuclear Power Technology Development Section
Division of Nuclear Power, Department of Nuclear Energy
SMRs Information available at IAEA

- SMR designs overview
IAEA ARIS database include SMR designs

Advanced Reactors Information System
• Main Features

- Design description and main features of 56 SMR designs
- SMRs are categorized in six (06) types based on coolant type/neutron spectrum:
  - Land Based WCRs
  - Marine Based WCRs
  - HTGRs
  - Fast Reactors
  - MSRs
  - Others
- MANY designs not included / not submitted
- **Next edition September 2020**
- Will use harmonized ARIS submissions to create the SMR booklet
- Invitations are being send out to vendors…
### SMR Designs Based on Power Range

<table>
<thead>
<tr>
<th>Power Range MW(e)</th>
<th>Reactor Designs</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt; 301</td>
<td>★ IMR ★ UKSMR ★ IRIS ★ VBER-300 ★ Westinghouse LFR</td>
</tr>
<tr>
<td>251-300</td>
<td>★ DMS ★ SC-HTGR ★ BREST-OD-300 ★ GT-MHR ★ Stable Salt Reactor</td>
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<tr>
<td>101-150</td>
<td>★ HTR-PM ★ CMSR ★ SVBR100 ★ SUPERSTAR</td>
</tr>
<tr>
<td>51-100</td>
<td>★ ACP100 ★ nuScale ★ SMART ★ ACP50S ★ MHR100 ★ MK1-PBFHR</td>
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<tr>
<td>0-50</td>
<td>★ CAREM25 ★ LFR-TL-X ★ CA Waste Burner ★ A-HTR-100 ★ SEALER ★ eVinci</td>
</tr>
</tbody>
</table>

*Reactors and their respective designations are categorized based on their power range, illustrating a comprehensive overview of small modular reactor (SMR) designs. Each range is accompanied by a selection of reactor designs, illustrating the diversity and innovation in SMR technology.*
### IAEA Member States with SMRs

<table>
<thead>
<tr>
<th>Argentina</th>
<th>South Africa</th>
<th>Indonesia</th>
<th>Republic of Korea</th>
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<tr>
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IAEA Activities

- Organizational structure
- Main areas and mechanisms available
- Coordinated Research Projects
- Publications
- Toolkits, Portals and Training Simulators
Nuclear Power Technology Development Section

Fostering information exchange and collaborative research and development for advanced nuclear reactor technologies, this Section provides information to the IAEA’s Member States on technology status and development trends for advanced reactor systems and their applications. Read more →

Nuclear Power Engineering Section

The Section supports countries operating nuclear power plants or expanding their existing programmes to improve engineering, performance, management systems, human resource management, stakeholder involvement and technical infrastructure. It shares best engineering practices and innovations consistent with the global objectives of nuclear safety, security and non-proliferation. Read more →

Nuclear Infrastructure Development Section

This Section is responsible for coordinating IAEA assistance to Member States considering or embarking on nuclear power programmes. It supports capacity-building, conducts review missions and offers guidelines, standards and workshops on developing the infrastructure for a safe, secure and sustainable nuclear power programme. Read more →

International Project on Innovative Nuclear Reactors and Fuel Cycles Section

The Section coordinates the activities of the membership-based International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) to increase international cooperation on global nuclear energy sustainability, long term strategies and institutional and technical innovations for nuclear energy development and deployment. Read more →
IAEA Programmatic Activities

1.1 Nuclear Power

1.1.1 Strengthening Integrated Engineering Support for Nuclear Power Programmes

1.1.2 Integrated Management and Human Resource Development for Nuclear Power

1.1.3 Infrastructure and Planning for New Nuclear Power Programmes

1.1.4 International Project on Innovative Nuclear Reactors and Fuel Cycles

1.1.5 Technology Development for Advanced Reactor and non-electric applications

1.1.5.1 (1000166) Technology development for water-cooled reactors

1.1.5.2 (1000153) Technology Development for small & medium-sized and modular reactors and gas-cooled reactors

1.1.5.3 (1000154) Advanced technology for fast reactors

1.1.5.4 (1000155) Non-electric applications of nuclear power

1.2 Nuclear Fuel Cycle and Waste Management

1.3 Capacity Building and Nuclear Knowledge for Sustainable Energy Development

1.4 Nuclear Science

1.3.1 Nuclear Techniques for Development and Environmental Protection

1.3.2 Nuclear Safety and Security

1.3.3 Nuclear Verification

1.3.4 Policy, Management and Administration Services

1.3.5 Management of Technical Cooperation for Development

Organizational structure:
Department of Nuclear Energy
Division of Nuclear Power
Nuclear Power Technology Development Section
NPTDS
Nuclear Power Technology Development Section

- Department of Energy
- Division Nuclear Power
- NPTDS currently works on all advanced and innovative reactor technologies
- Provides support to member states on all issues related to technology
- Has a number of technical working group driving its work in order to implement the GC resolution
Programme Activities: TWGs, Conferences, CRPs, International Experts Meetings, TMs

Technical Working Groups

- TWG-ND: 14
- TWG-LWR: 22
- TWG-HWR: 7
- TWG-GCR: 17
- TWG-FR: 27
- TWG-SMR: 20
- TWG-HWR: 7
- TWG-GCR: 17
- TWG-ND: 14
International Technical Working Group on SMR

- To advice and support IAEA programmatic planning and implementation in areas related to technology development, design, deployment and economics of SMRs
- 1st meeting in 2018 with 14 Member States
- Now 20 Member States and two International Organizations: European Commission and OECD-NEA as invited observers:

- Three technical subgroups established in 2018:
  - SG-1: Development of Generic Users Requirements and Criteria (GURC)
  - SG-2: Research, Technology Development and Innovation; Codes and Standards
  - SG-3: Industrialization, design engineering, testing, manufacturing, supply chain, and construction technology
- TWG will also address SMR for Non-Electric Applications and coupling with renewables
- 1st TWG Meeting for SMR held on 23 - 26 April 2018 in Vienna
- 2nd Meeting : 8 – 11 July 2019 in Vienna
International Technical Working Group on SMR

1st TWG (2018) main recommendation and proposed future activities

• The TWG-SMR TOR should explicitly state “including non-electrical applications and cogeneration”, to enable it to fulfil its full role.

• NE and TWG-SMR should support the technology development of innovative, smart/intelligent systems; making SMRs intrinsically safe, manoeuvrable, with enhanced operability and possible remote support.

• Development of Generic Users Requirements and Criteria (GURC) and include:
  – (i) Safety Considerations;
  – (ii) Siting requirements;
  – (iii) Operational requirements, and
  – (iv) Non-electric applications.
  – As Step-2 Derive Technical Requirements from the user identified priorities to make a choice of a SMR technology or design including economic considerations.

• To support near term deployment of SMRs the agency can assist Member States by arranging activities, conduct meetings or write reports on
  – (i) the ‘families of technology’ considered as near term deployable;
  – (ii) the identification of neutral/common areas of supply chain e.g. construction and manufacture that can be enhanced, and
  – (iii) learning from other industries e.g. aviation, oils and gas.
INPRO Dialogue Forum 17 in Coordination with NPTDS

“Opportunities and Challenges in Small Modular Reactors”

- Venue: Ulsan, Republic of Korea, 2-5 Jul 2019
- Plenary Technical Sessions:
  - Research & Technology Development
  - Market Opportunities
  - Design Requirements
  - Near Term Deployment Designs
    - 6 vendor presentations
    - 14 Member State presentations
- 140 participants from 23 Member States and International Organizations
- 6 Sessions and 27 Presentations in 3 Days
- Technical Tours to local nuclear sites and industry

https://nucleus.iaea.org/sites/INPRO/Pages/df-17.aspx
INPRO DF7 “Opportunities and Challenges in Small Modular Reactors”

Specific feedback on NPTDS presentation on SMRs and recommendations:

• CRPs early announcements:
  – Organizations in MS are not aware of CRP projects when they are initiated (only become aware later)
  – IAEA to find a way in addition to the official announcements to reach interested organizations

• Request to IAEA to provide information / report on near term or future SMR global market
  – To be considered at this TWG-SMR meeting; may be performed by IAEA/NEPIK/PESS
  – Not IAEA function? – report by OECD exist

• Proposed future CRP on SMR deployment in grid systems with large penetration of renewables

• IAEA to promote standardization (why so many SMR designs)
  – Not IAEA role – may be facilitated by User Requirements

• Platform for developers and embarking countries/ vendors to etc connected
  – Not IAEA role – ARIS and SMR booklet, Reactor Technology Assessment

• Develop of SMR specific standards and guidance (licensing, infrastructure needs, technology assessment, etc.)
Should SMR designers have a general design principle to employ passive safety systems?

- 47: Yes, it will add to safety and public acceptance
- 10: Yes, but only if
- 15: No, a good balance between active and passive features are needed
The reliability of passive safety systems

- Unreliable since they depend on small forces (like natural convection) - 2
- Reliable since they obey the laws of nature - 14
- Always must be demonstrated in experiments first - 55
Integration with intermittent renewables are essential for SMRs future success
A reduction in Emergency Planning Zone is essential for future deployment of SMRs

No, we should always prepare the public for any eventuality (it is the last level of DiD)

Yes, I agree, it should be on the site boundary

17
43
INPRO DF17 – participants response

SMRs should rather focus on niche markets where large NPPs cannot compete
Opportunities

1. Climate Change
2. Safety
3. Simplicity
4. Flexible Application
5. Capital Cost
6. Flexible Deployment

Challenges

1. Policies
2. Licensing
3. Security & Safeguards
4. Implementation
5. LCOE
SMR: Ongoing Support to Member States through TC

Ongoing SMR/HTGR Missions
- Indonesia
- Jordan
- Saudi Arabia

Technical Cooperation Project: Europe/Eurasia
- Armenia
- Azerbaijan
- Croatia
- Czechia
- Hungary
- Lithuania
- Poland
- Romania
- Russia
- Slovakia
- Tajikistan
- Ukraine

Common Themes / actual activities:
- Design and technology status of water-cooled SMRs / non-water cooled SMRs
- Non-electric nuclear applications, options, technology readiness and toolkits
- Technology Assessment training
- Infrastructure, economic and financing aspects of SMRs
- Design Specific Issues on Engineering Project, Construction and Industrial Supply Chain for Small Modular Reactor Deployments
- Siting of SMRs
- SMR deployment scenarios in global energy portfolio
- Design safety and safety assessment of SMRs
- Principles for Emergency Preparedness & Response for SMRs
- SMR fuel cycles and waste management (specifically also for HTGRs)
- Construction technology and management
Project Facts: RER2014

• Title: *Facilitating Capacity Building for Small Modular Reactors: Technology Developments, Safety Assessment, Licensing and Utilization*

• Budget: EUR 450,450
  – Approved Budget TCF: EUR 355,950
  – Extrabudgetary contribution (footnote-a/): EUR 94,500

• Duration: 2 years (Jan 2018 - Dec 2019)

• Participating Member States: 16
<table>
<thead>
<tr>
<th>Activity</th>
<th>Venue</th>
<th>Comment</th>
<th>Quarter</th>
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<tr>
<td>Coordination Meeting</td>
<td>Vienna, Austria: 13-15 March 2018</td>
<td>Completed</td>
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<tr>
<td>Panel at Technology Developments in SMR at HND2018</td>
<td>Zadar, Croatia: 03-06 June 2018</td>
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<tr>
<td>Workshop on design and technology status of water cooled SMRs for near term development</td>
<td>Vienna, Austria: 24-26 September 2018</td>
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<tr>
<td>Workshop on Infrastructure, economic and financing aspects of SMRs</td>
<td>Vienna, Austria: 01-05 October 2018</td>
<td>Completed</td>
<td>Q4</td>
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<tr>
<td>Workshop on design and technology status of innovative (non water cooled) SMRs for near term development</td>
<td>Vienna, Austria: 29 October - 02 November 2018</td>
<td>Completed</td>
<td>Q4</td>
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<tr>
<td>Workshop on non-electric nuclear applications: Options, technology readiness and available IAEA toolkits.</td>
<td>Prague, Czech Republic, 11 – 13th February 2019</td>
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<td>Prague, Czech Republic, 11 – 13th Feb 2019</td>
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<td>Workshop on technology assessment of SMRs</td>
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<td>Regional Workshop on SMR deployment scenarios in global energy portfolio</td>
<td>Pitesti, Romania, 24-28 June 2019</td>
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<tr>
<td>Regional Workshop on Design Specific Issues on Engineering Project, Construction and Industrial Supply Chain for Small Modular Reactor Deployments</td>
<td>Otwock-Swierk, Poland, September</td>
<td>Proposed 18-22 November</td>
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### RER2014 Workplan (3)

Activities to be implemented by Nuclear Safety and Security Department

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<th>Activity</th>
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<tr>
<td>Regional Workshop on design safety, safety assessment and site evaluation of SMRs</td>
<td>Vienna, 28-31 October 2019</td>
<td>Audience: Regulatory bodies</td>
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<tr>
<td>Regional Workshop on the principles for Emergency Preparedness &amp; Response for SMRs</td>
<td>Vienna, 29-31 October 2019</td>
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<tr>
<td>Workshop on regulatory framework and licensing issues for SMR development</td>
<td>18-22 November 2019</td>
<td>Audience: Regulatory bodies; regulatory experience from UK and Canada to be shared</td>
<td>Q4</td>
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Project Facts: RER2018008

- **Working Title:** *Low carbon energy generation and climate change: assessing energy technologies*
- **Duration:** 2 years (TC Cycle 2020/2021)
- **Participating Member States:** 33 (at the moment)

**Suggested focus of the project**
- Economic and financial analysis of low carbon energy technologies
- Security of energy supply and flexibility of electricity production with high penetration of RE (including SMR)
- Nuclear technology acceptability by public and means of communication (i.e. SMRs in dense inhabited areas)
- Prospects of co-generation such as SMRs for district heating utilization

**Activities:**
- Workshops, Regional and National Training Courses, Expert Assignments and development of case studies and reports on above mentioned topics

**Key for a successful and impactful project**
- Strong commitment of all the participants and active participation from the very beginning;
- Creating of a network of experts that forms a nexus of the following areas: Climate Change, Nuclear Power (including SMRs) and Energy Economics
Coordinated Research Projects

- Projects and status
CRPs relevant to SMRs

1. High Temperature Gas Cooled Reactor Physics, Thermal-Hydraulics and Depletion Uncertainty Analysis

2. High Temperature Gas Cooled Reactors Safety Design

3. HTGRs applications for energy neutral sustainable comprehensive extraction and mineral products development (T11006 - with NEFW-NFCM)

4. Development of Approaches, Methods and Criteria for Determining Technical Basis for EPZ for SMR Deployment (joint project – presented later)

Many SMR designs adopt advanced passive safety systems to cope with both design basis- and design extension conditions.

**Objective:** provide common approaches to design and to enhance the performance of passive safety features in integral-PWR SMRs

- Provide methods for assessing their performance and reliability
- Perform verification & validation of computer codes for the performance analyses using experimental date from separate/integral effect tests
- Define future R&D needs on advanced passive safety systems

3 Year project from July 2017 until July 2020

CRP I3 2010 with 10 participants from 10 MSs

- Argentina, Canada, China, Egypt, India, Indonesia, Italy, Republic of Korea, Lithuania, Pakistan, and United Kingdom
- RCM-1 took place on 30 Oct – 3 Nov 2017
- RCM-2 took place on 7 – 10 May 2018
- RCM-3 planned for 3 - 6 September 2019 in Korea
CRP on EPZ for SMR deployment

- SMR features that may impact EPZ
  - Strengthened safety features
  - Lower probability of releases
  - Time of onset and duration of the release

- The uncertainties about emergency status and evolution may still be high for FOAK.

- Joint CRP with NPTDS and NSNI Regulatory Activities Section (RAS) and Emergency Information Centre (EIC)
- To develop approaches and methodologies for determining the need for off-site EPR including the size of EPZs for SMRs (using IAEA requirements as the basis)
- Project duration: 1 January 2018 – 31 December 2020
- CRP31029: 19 participants from 14 MS: Argentina, Canada, China(3), Finland, Indonesia, Israel, Japan, Korea, Netherlands (JRC-Petten), Pakistan, Saudi Arabia, Tunisia, UK(2), USA(3)
- RCM-1 took place May 14-17 2018
- RCM-2 took place May 27-31 2019 in Beijing, China
- RCM-3 planned for May 2020 in Vienna
Planned CRPs for the P&B 2020/21

2020: Technologies to enhance the competitiveness and early deployment of SMRs and HTRs
(TWG-GCR)

2021: CRP on the experimental facility and prototype testing needs for validation and to enhance near-term SMR deployment
(TWG-SMR)
2020: Technologies to enhance the competitiveness and early deployment of SMRs and HTRs

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<td>Project name</td>
<td>1.1.5.002 Technology development for small and medium-sized or modular reactors</td>
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<td>Task Number</td>
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<td>Task Type</td>
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<td>CRP HTGR_Applic</td>
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<tr>
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<td>Technologies to enhance the competitiveness and early deployment of SMRs and HTRs</td>
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- The CRP will study technologies related to reactor design and innovative power conversion of SMRs and HTRs to enhance the competitiveness and possibilities for deployment.
- The CRP will perform research and exchange information on technology developments and novel solutions to enhance the competitiveness of SMRs and HTGRs.
- This includes aspects such as reactor core and NPP designs for novel applications:
  - Long-life core loads
  - Load follow capabilities
  - Applications for mines that need cogeneration or tri-generation, i.e. electricity, heat and cooling,
  - Hybrid systems (also to support intermitted renewables on the grid),
  - Off-grid applications (islands, isolated communities),
  - Innovative power conversion systems (for example co-firing with gas or heat storage systems),
  - Dry cooling (for desert applications).
- It may also include the need for new reactor designs, enhancement in fuel, increased safety, flexible operational modes, waste solutions and enhanced economics. These proposed enhancements should improve the sustainability of the technology and facilitate earlier and increased deployment.
2021: CRP on the experimental facility and prototype testing needs for validation and to enhance near-term SMR deployment

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</tbody>
</table>

- A new CRP on the experimental facility and prototype testing needs for validation, especially to determine the probable requirements to enhance demonstration and licensing.
- The aim is to support the near-term deployment of SMRs.
- Possible topics to consider:
  - Industrialization
  - design engineering
  - Testing
  - Manufacturing
  - supply chain
  - construction technology
Other initiatives

PUI funding proposal

- This project will support embarking countries interested in the deployment of SMRs, by providing a full set of IAEA services and tools including:
  - Dedicated reactor technology assessment (RTA) and e-Toolkit for SMRs (e-RTA) to help in assessing various SMR technologies.
  - Generic User Requirements and Criteria of SMRs and their Applications for Embarking Countries (SMR-GURC) to detail specific technical/design, safety and economic characteristics and relevant fuel cycle options including waste management facilities and non-electric applications.
  - Training courses, workshops, basic principle simulators, guidelines for an integrated and systematic learning-by-doing education and training, specifically tailored for SMR deployment and human capacity development.
  - SMR Connect Platform (SMR-NET) available for professional networks or communities of practice and their members.

https://www.iaea.org/sites/default/files/18/08/pui-projectupdates_full_august_17_nuclear_energy.pdf
• Published
• Planned
Recent Publications and Forthcoming Ones

- NES Technology Roadmap for Small Modul Reactor Deployment
- TECDOC: Status of Approaches for Environmental Impact Assessment for SMR Deployment
- TECDOC: Options to Enhance Energy Supply Security using Hybrid Energy Systems
SMR Deployment Indicators are evaluated in the following categories:

<table>
<thead>
<tr>
<th>National Energy Demand</th>
<th>SMR Energy Demand</th>
<th>Financial/Economic Sufficiency</th>
<th>Physical Infrastructure Sufficiency</th>
<th>Climate Change Motivation</th>
<th>Energy Security Motivation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Growth Rate of Primary Energy Consumption (GRPEC)</td>
<td>Co-Generation (DESAL/DH)</td>
<td>Openness to International Trade (FDI/TRADE)</td>
<td>Infrastructure Conditions (INFRA)</td>
<td>Reduce Fossil Fuel-Energy Consumption (FOSSFUEL/OGC)</td>
<td>Use Domestic Uranium Resources (URAN)</td>
</tr>
</tbody>
</table>

Published in September 2018
Role of SMRs in Climate Change

SMR Renewables Hybrid Energy System to Reduce GHG Emission

TECDOC on Options to Enhance Energy Supply Security using Hybrid Energy Systems based on SMR – Synergizing Nuclear and Renewables; being finalised

Exploring Synergies between Nuclear and Renewables: IAEA Meeting Discusses Options for Decarbonizing Energy Production and Cogeneration
Upcoming Events and Meetings

- Meetings
- Workshops
- Conferences
Meetings - 2019

• Technical Meeting on Benefits and Challenges of Fast Reactors of SMR Type; 24-27 September 2019.

• Technical Meeting of the Technical Working Group on Gas Cooled Reactors (TWG-GCR); 11 – 13 Nov 2019

• Technical Meeting on Technologies to Enhance the Competitiveness and Early Deployment of SMRs and HTGRs; 14-15 Nov 2019

• Technical Meeting on Design, Experimental Validation and Operation Aspects of Small and Medium Sized or Modular Reactors; 18-22 November 2019, Islamabad, Pakistan

• Joint IAEA–GIF Technical Meeting on the Safety of High Temperature Gas Cooled Reactors; 9-12 December 2019
ICTP-IAEA Workshop Course
Joint ICTP-IAEA Workshop on Physics and Technology of Innovative High Temperature Nuclear Energy Systems (SMR 3281)
14 – 18 October 2019, Trieste, Italy

Still open for applications till 28 JULY 2019

http://indico.ictp.it/event/8725/

Joint ICTP-IAEA Workshop on Physics and Technology of Innovative High Temperature Nuclear Energy Systems | (smr 3281)

Starts 14 Oct 2019
Central European Time

ICTP
Kastler Lecture Hall (AGH)
Strada Costiera, 11
I - 34151 Trieste (Italy)
## Proposed meetings 2020

<table>
<thead>
<tr>
<th>Date</th>
<th>Event Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-17 March 2020</td>
<td>14th GIF-IAEA Interface Meeting</td>
</tr>
<tr>
<td>6-8 April 2020</td>
<td>Technical Meeting on Technologies to Enhance the Deployment and Competitiveness of Advanced SMRs</td>
</tr>
<tr>
<td>26-29 May 2020</td>
<td>Third Research Coordination Meeting on Development of Approaches, Methodologies and Criteria for Determining the Technical Basis for Emergency Planning Zone for Small Modular Reactor Deployment</td>
</tr>
<tr>
<td>29 June - 2 July 2020</td>
<td>Third Meeting of the Technical Working Group on Small and Medium Sized or Modular Reactors</td>
</tr>
<tr>
<td>13-15 July 2020</td>
<td>Workshop on High Temperature Gas Cooled Reactor Technology</td>
</tr>
<tr>
<td>31 Aug - 2 Sept 2020</td>
<td>Fourth Research Coordination Meeting on Design and Performance Assessment of Passive Engineered Safety Features in Advanced Small Modular Reactors</td>
</tr>
<tr>
<td>19-22 October 2020</td>
<td>Technical Meeting on generic user requirements for near term deployment of SMRs and their application</td>
</tr>
<tr>
<td>5 - 8 August 2020</td>
<td>Technical Meeting on Isotope Production in Large WCRs and SMRs</td>
</tr>
<tr>
<td>5-6 Nov 2020</td>
<td>Technical Meeting on the Status of the IAEA Nuclear Graphite Knowledge Base</td>
</tr>
<tr>
<td>9 - 12 November 2020</td>
<td>First Research Coordination Meeting on Technologies to Enhance the Competitiveness and Early Deployment of High Temperature Reactors and SMRs</td>
</tr>
<tr>
<td>2 - 4 December 2020</td>
<td>Second Joint IAEA–GIF Technical Meeting on the Safety of High Temperature Gas Cooled Reactors</td>
</tr>
</tbody>
</table>
Thank you!

For inquiries on SMR, please contact:

Mr Frederik Reitsma
Team Leader: SMR Technology Development
IAEA Nuclear Power Technology Development Section

F.Reitsma@iaea.org
## Status and major accomplishment in Technology Developer Countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Recent Milestone</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Argentina</strong></td>
<td>CAREM25 is in advanced stage of construction. Aiming for fuel loading &amp; start-up commissioning in 2019</td>
</tr>
</tbody>
</table>
| **Canada**        | CNSC is performing design reviews for several innovative SMR designs, mostly non-water cooled, including molten salt reactors (MSR)  
                      First Canadian SMR licence application submitted: Global First Power (GFP), with support from Ontario Power Generation and Ultra Safe Nuclear Corporation (USNC), **to deploy a Micro Modular Reactor plant at Chalk River in Ontario** |
| **China**         | • HTR-PM is in advanced stage of construction. Commercial operation expected in 2019.  
                      • ACP100 completed IAEA generic reactor safety review. CNNC plans to build ACP100 demo-plant in Hainan Provence in the site where NPPs are already in operation.  
                      • China has 3 floating SMR designs (ACP100S, ACPR50S and CAP-F) |
| **France**        | • Propose a new French SMR design (Consortium of TechnicAtome, CEA, EDF, Naval Group, Investir L`Avenir)                                      |
| **Republic of Korea** | SMART (100 MWe) by KAERI certified in 2012.  
                      • SMART undertakes a pre-project engineering in Saudi Arabia, for near-term construction of 2 units.  
                      • Updated design with increased power and more passive safety features developed  
                      • New design will be submitted for certification in Korea in parallel with KSA licensing application |
| **Russian Federation** | • Akademik Lomonosov floating NPP with 2 modules of KLT40S has completed construction and commissioning. Aiming for criticality and test operations in 2019.  
                      • AKME Engineering will develop a deployment plan for SVBR100, a eutectic lead bismuth cooled, fast reactor. |
| **United Kingdom** | • Rolls-Royce recently introduced UK-SMR, a 450 MW(e) PWR-based design; many organizations in the UK work on SMR design, manufacturing & supply chain preparation  
                      • Identifying potential sites for future deployment of SMR;  
                      • Government supporting 8 advanced designs (Phase I) to determine its feasibility |
| **United States of America** | • The US-NRC has started design review for NuScale (720 MW(e) from 12 modules) from April 2017, aiming for FOAK plant deployment in Idaho Falls. |
### Status and major accomplishment in Embarking Countries

<table>
<thead>
<tr>
<th>Countries</th>
<th>Recent Milestone</th>
</tr>
</thead>
</table>
| Saudi Arabia| • Vision 2030 → National Transformation Program 2020: Saudi National Atomic Energy Project:  
• K.A.CARE performs a PPE with KAERI to prepare a construction of 2 units of SMART  
• An MOU between K.A.CARE and CNNC on HTGR development/deployment in KSA |
| Indonesia   | • Through an open-bidding, an experimental 10 MW(th) HTR-type SMR was selected in March 2015 for a basic design work aiming for a deployment in mid 2020s  
• Site: R&D Complex in Serpong where a 30 MW(th) research reactor is in operation  
• BAPETEN, the regulatory body has issued a site license |
| Jordan      | • Jordan, Saudi Arabia and Republic of Korea is to conduct a feasibility study for a deployment of SMART in Jordan |
| Poland      | • HTGR for process heat application to be implemented in parallel to large LWRs  
• 10 MW(th) experimental HTGR at NCBJ proposed possibly with EU cooperation |
| Tunisia     | • STEG, the National Electricity and Gas Company is active in performing technology assessment for near-term deployable water-cooled SMRs |
| Kenya       | • Requested support on human capacity building for Reactor Technology Assessment that covers SMRs through IAEA-TC Project |
Near-Term Deployment SMR designs

**CAREM25**

- Integral PWR Generation III+
- 32 MW(e) x 1 module
- 55% progress of construction in the Atucha site
- Target commissioning date: September 2021

**ACP100**

- Integral PWR Generation III+, 100 MW(e)
- Conducted IAEA Generic Safety Review
- 1 FOAK unit to be constructed in China from December 2019

**HTR-PM**

- High Temperature Gas-cooled Pebble-bed Modular Reactor
- 250 MW(th) per module
- In commissioning in Shidao Bay, China
- Promised short construction schedule
- A cooperation on R&D to support Indonesia capacity building is ongoing
Near-Term Deployment SMR designs

Facts:
- Integral PWR Generation III+
- 110 MW(e)
- Standard Design Approval in 2012
- 2 FOAK units to be constructed in Saudi Arabia by mid-2020s
- SMART100 for SDA in 2021

Facts:
- Integral PWR Generation III+
- 50 MW(e) x 2 modules
- Already deployed as nuclear icebreakers (2 units)
- Floating and land-based versions for import

Facts:
- Integral PWR Generation III+
- 60 MW(e) x 12 modules
- Undertaking NRC Design Certification Review since 2017
- 1 FOAK unit (12 modules) to be constructed in Idaho Falls from 2022
<table>
<thead>
<tr>
<th>Vendor</th>
<th>Name / cooling type</th>
<th>Applied for (MWe)</th>
<th>Review start date</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terrestrial Energy Inc.</td>
<td>IMSR Integral Molten Salt Reactor</td>
<td>200</td>
<td>Phase 1 April 2016</td>
<td>Phase 1 complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Phase 2 December 2018</td>
<td>Phase 2 assessment in progress</td>
</tr>
<tr>
<td>NuScale Power, LLC</td>
<td>NuScale Integral Pressurized Water Reactor</td>
<td>50</td>
<td>Phase 2* April 1, 2019</td>
<td>Service agreement signed. Assessment pending</td>
</tr>
<tr>
<td>Ultra Safe Nuclear Corporation / Global First Power</td>
<td>MMR-5 and MMR-10 High Temperature Gas</td>
<td>5-10</td>
<td>Phase 1 December 2016</td>
<td>Phase 1 complete</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Phase 2 Pending</td>
<td>PHASE 2 Service Agreement in place – Project start pending</td>
</tr>
<tr>
<td>Westinghouse Electric Company, LLC</td>
<td>eVinci Micro Reactor Solid core and heat pipes</td>
<td>up to 25 MWe</td>
<td>Phase 2* Pending early 2019</td>
<td>Service agreement under development</td>
</tr>
<tr>
<td>LeadCold Nuclear Inc.</td>
<td>SEALER Molten Lead</td>
<td>3</td>
<td>Phase 1 January 2017</td>
<td>Phase 1 on hold at vendor’s request</td>
</tr>
<tr>
<td>Advanced Reactor Concepts Ltd.</td>
<td>ARC-100 Liquid Sodium</td>
<td>100</td>
<td>Phase 1 Fall 2017</td>
<td>Assessment in progress</td>
</tr>
<tr>
<td>URENCO</td>
<td>U-Battery High-Temperature Gas</td>
<td>4</td>
<td>Phase 1 To be determined</td>
<td>Service agreement under development</td>
</tr>
<tr>
<td>Moltex Energy</td>
<td>Moltex Energy Stable Salt Reactor Molten Salt</td>
<td>300</td>
<td>Series Phase 1 and 2 December 2017</td>
<td>Phase 1 assessment in progress</td>
</tr>
<tr>
<td>SMR, LLC. (A Holtec International Company)</td>
<td>SMR-160 Pressurized Light Water</td>
<td>160</td>
<td>Phase 1 July 2018</td>
<td>Assessment in progress</td>
</tr>
<tr>
<td>StarCore Nuclear</td>
<td>StarCore Module High-Temperature Gas</td>
<td>10</td>
<td>Series Phase 1 and 2 To be determined</td>
<td>Service agreement under development</td>
</tr>
</tbody>
</table>
• The Canadian Nuclear Safety Commission (CNSC) has received the first licence application for a small modular reactor.
• The application from Global First Power (GFP), with support from Ontario Power Generation and Ultra Safe Nuclear Corporation (USNC), supports a proposal to deploy a Micro Modular Reactor plant at Chalk River in Ontario.
  – in response to an invitation issued in April 2018 by Canadian Nuclear Laboratories (CNL) to SMR project proponents for the construction and operation of an SMR demonstration unit at a CNL-managed site.
• The MMR is a 15 MW (thermal), 5 MW (electrical) high-temperature gas reactor
  – the reactor uses fuel in prismatic graphite blocks
  – TRISO coated particle fuel encased within a fully dense silicon carbide matrix
• MMR technology would serve as a model for future off-grid SMR deployment in Canada, to provide low-carbon energy and heat to remote industry and northern communities
15 key RTA Elements

A new Toolkit to help embarking countries in applying the IAEA methodology on Reactor Technology Assessment

Old design

New design
SMR Simulator for Education

**iPWR Simulator**, available to download for free

- 150 MWth, integral type PWR, 14 systems including various integrated passive safety systems

**Passive systems**
- Automatic Depressurisation system (ADS)
- Pressure Injection system (PIS)
- Gravity Injection system (GIS)
- Passive heat removal system (PDHR)

**Planned SMR Simulator**, advanced and innovative reactors

- Based on HTGR design (Technical specifications available; INET, China offer a simulator – under development)
- Based on SFR design (Technical specifications available)