IAEA
International Atomic Energy Agency
Atoms for Peace and Development

The IAEA Activities on Advanced Reactors Technology and SMRs

Frederik Reitsma

Team Leader (SMR Technology Development)
Nuclear Power Technology Development Section
Division of Nuclear Power, Department of Nuclear Energy

Joint IAEA-ICTP Workshop on the Physics and Technology of Innovative High Temperature Nuclear Energy Systems

IAEA
International Atomic Energy Agency
Atoms for Peace and Development

IAEA Activities

- Organizational structure
- Member State defining the project
- Main areas and mechanisms available
- Coordinated Research Projects
- Publications
- Future needs
- Toolkits, Portals and Training Simulators

Nuclear Power Technology Development Section
Division of Nuclear Power
Department of Nuclear Energy

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 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 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

IAEA

Major Programme

- **MP1** Nuclear Power, Fuel Cycle and Nuclear Science
- **MP2** Nuclear Techniques for Development and Environmental Protection
- **MP3** Nuclear Safety and Security
- **MP4** Nuclear Verification
- **MP5** Policy, Management and Administration Services
- **MP6** Management of Technical Cooperation for Development

Programme

- 1.1 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

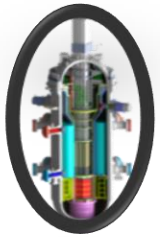
Sub Programme

- 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

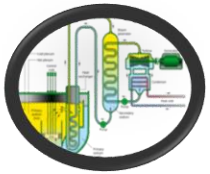
Projects

- 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

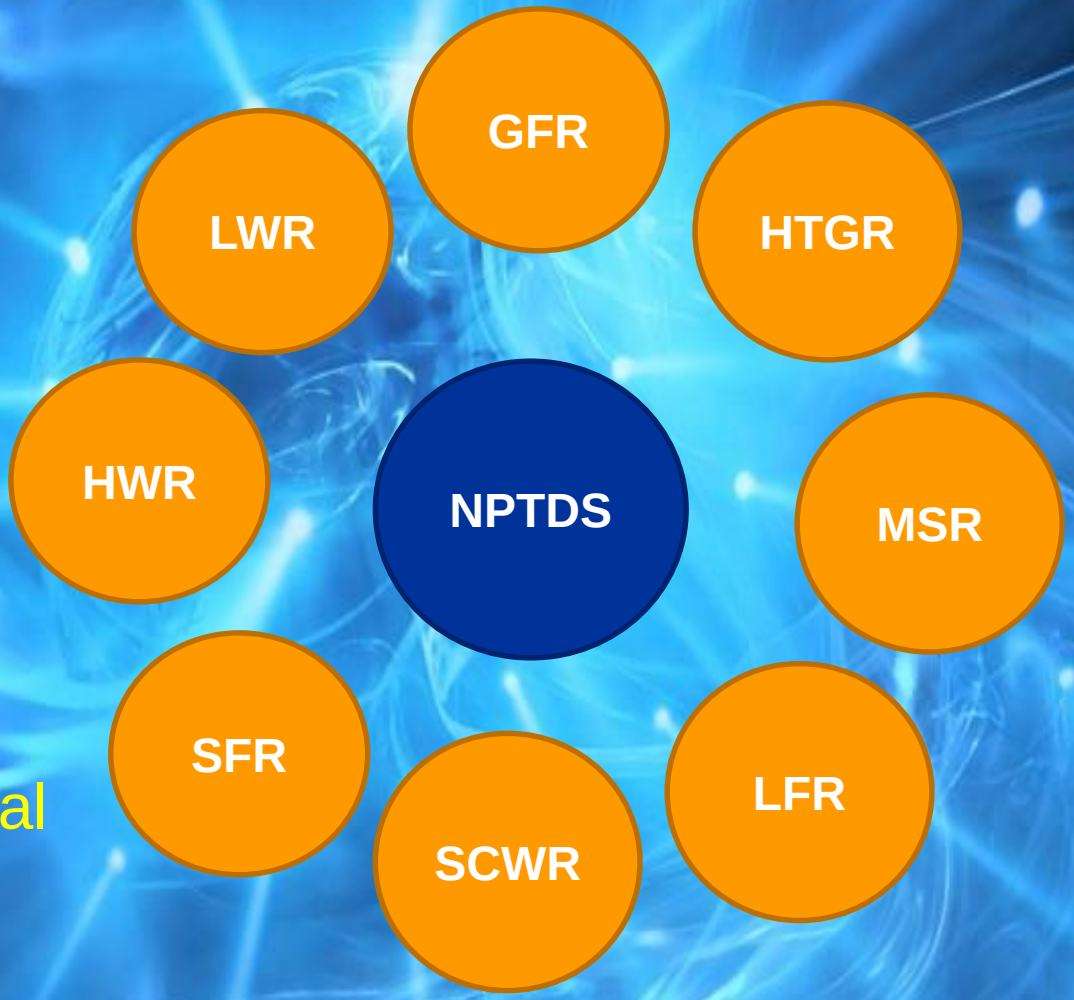
Organizational structure:

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

Collaborating Centers

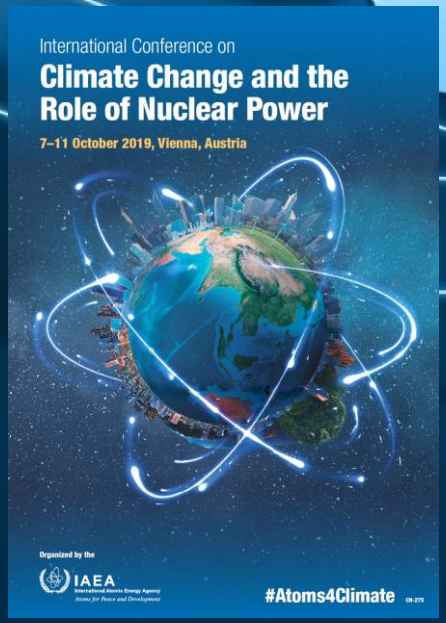
Coordinated Research Projects

Technical Meetings

Training and Workshops

Technical Working Groups

Conferences



GC events

Reactor Technology Innovation to Support Integration of Renewable Energy Systems and Nuclear Installations

Wednesday, 18 September 2019, 14:00–16:00
M7, M building, ground floor

TWG-SMR: 20

TWG-LWR: 22

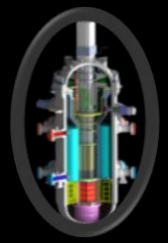
TWG-HWR: 7

TWG-FR: 27

TWG-GCR: 17

TWG-ND : 14

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



Reactor Technology Innovation to Support Integration of Renewable Energy Systems and Nuclear Installations

GC63 side event

- well attended with at least 80 people
- both A/DG C. Feruta and DDG-NE M. Chudakov were present to give opening remarks
- six panellists presented the main aspects

Wednesday, 18 September 2019, 14:00–16:00

Aspects discussed included

- current large NPP load following capabilities
- integration with renewables and non-electric applications of nuclear power.
- Future flexibility needs necessity for a transition to increased renewable energy loaded grid.
- Product diversity with non-electric applications such as hydrogen production
  - Hydrogen production is a key method for decarbonization of the steel industry in Japan
  - Process heat from solar and nuclear plants with flameless calcination is a key method for decarbonization several industries
  - Desalination and the use of process heat with the chemical and petroleum industries and district heating.
  - The IAEA participates in activities to support the integration of renewable energy systems and nuclear installations through technical meetings, toolkits and databases, and publications.

Nuclear and Renewables: Playing Complementary Roles in Hybrid Energy Systems

Shant Krikorian, IAEA Department of Nuclear Energy

SEP 18 2019

Wind turbine and the Tricastin Nuclear Power Plant in Saint-Paul-Trois-Châteaux, France. (Photo: Getty)

A hybrid energy system combining both nuclear power and renewables can help significantly reduce greenhouse gas (GHG) emissions, according to participants at an event held today on the sidelines of the IAEA's 63rd General Conference.

Related Stories

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

Future of Low Carbon Energy Systems: IAEA Workshop Reviews Potential Uses of Small Modular Reactors

Nuclear Energy for the Future

How the IAEA Will Contribute to the Sustainable Development Goals

Related Resources

63rd IAEA General Conference, 16-20 September 2019

Energy

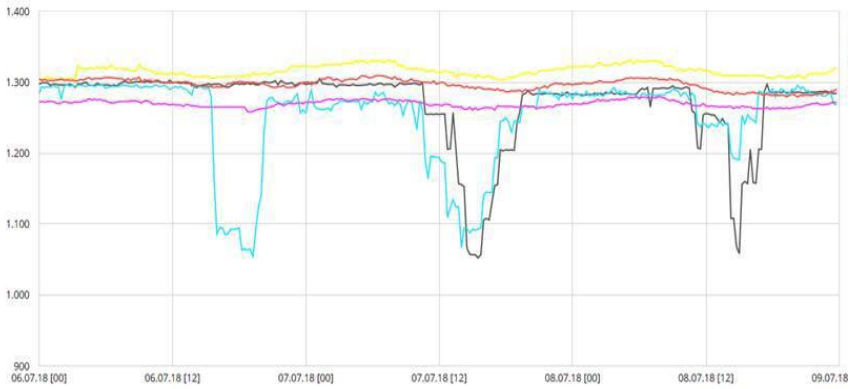
https://www.iaea.org/newscenter/news/nuclear-and-renewables-playing-complementary-roles-in-hybrid-energy-systems

Reactor Technology Innovation to Support Integration of Renewable Energy Systems and Nuclear Installations

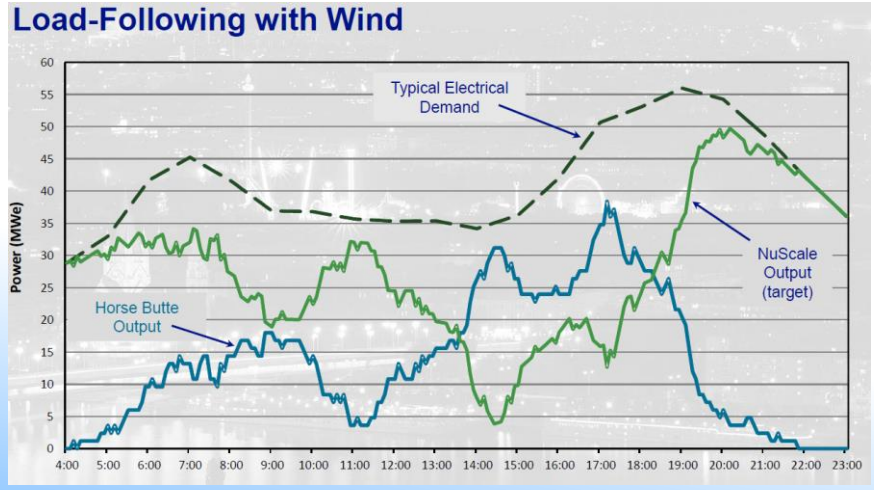
GC63 side event

IAEA

In Germany NPPs flexibility is a reality



SMR NuScale abilities enhanced with modular flexibility



- **Industry experience in managing NPPs in a grid with a large share of renewable energy sources**
- **Mr Denis JANIN**, Portfolio Manager, Preussen Elektra, Germany

- **Beyond baseload: NuScale SMR flexibility and integration with renewables**
- **Ms Lenka KOLLAR**, Director, Strategy & External Relations, NuScale Power, USA

- **Nuclear energy reimagined: U.S. development of integrated energy systems**
- **Mr John C. WAGNER**, Associate Laboratory Director, Idaho National Laboratory, USA

- **Advanced process heat applications with solar and nuclear for full substitution of fossil fuels**
- **Mr Nils HANEKLAUS**, Researcher, RWTH Aachen University, Germany

- **Japan's HTGR development programme and potential for non-electric applications**
- **Mr Taiju SHIBATA**, Leader, International Cooperation Group, Japan Atomic Energy Agency (JAEA), Japan

- **IAEA activities on nuclear-renewable hybrid energy systems and the ARIS database**
- **Ms Tatjana JEREMOVIC**, Team Leader, WCR Technology Development, Nuclear Power Technology Development Section, IAEA Department of Nuclear Energy

Chair: Stefano MONTI
Section Head, Nuclear Power Technology Development Section

Scientific Secretaries: Frederik REITSMA, Ibrahim KHAMIS Nuclear Power Technology Development Section

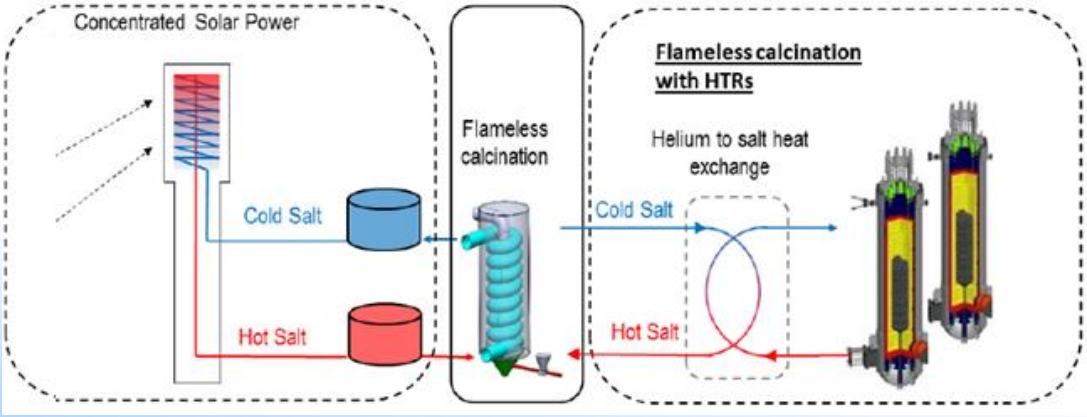
Reactor Technology Innovation to Support Integration of Renewable Energy Systems and Nuclear Installations

GC63 side event

IAEA

A new paradigm for nuclear energy

Flameless Calcination of Minerals



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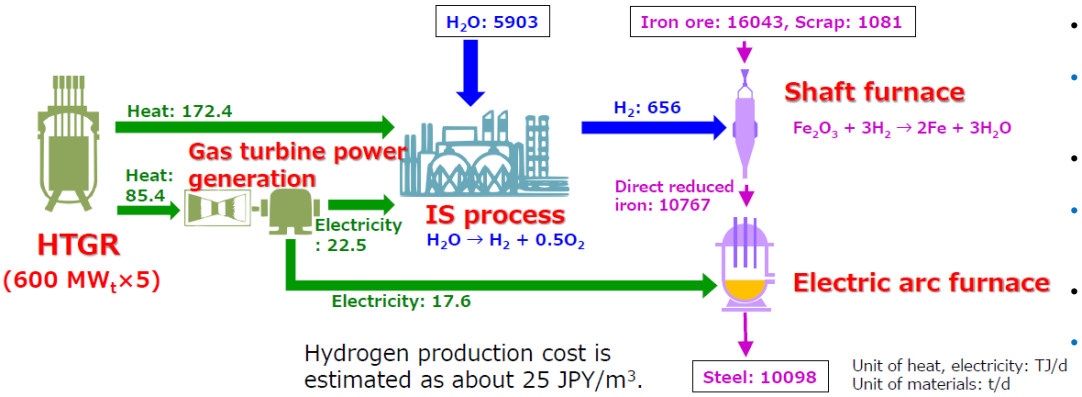
Reactor Technology Innovation to Support Integration of Renewable Energy Systems and Nuclear Installations

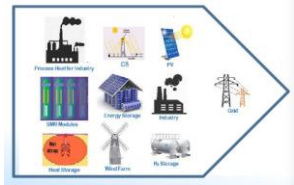
GC63 side event

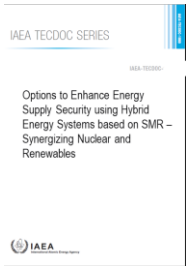
IAEA

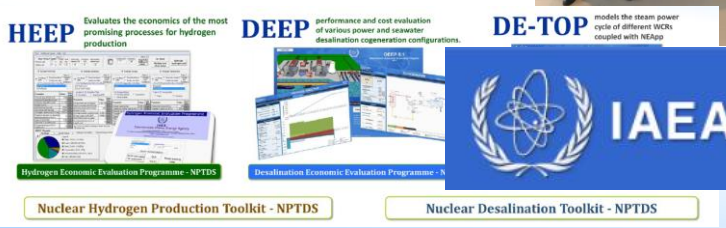
CO_2 emission from steel plants can be cut by 100 %



IAEA support activities on Nuclear-Renewable Hybrid Energy Systems







IAEA | ARIS Advanced Reactors Information System

- **Industry experience in managing NPPs in a grid with a large share of renewable energy sources**
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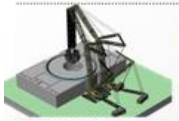
Project on Small and Medium Sized and Modular Reactors

– All advanced technologies included

Economic
- Lower Upfront capital cost
- Economy of serial production



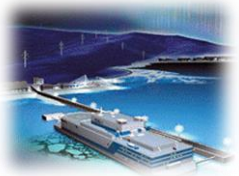
Modularization
- Multi-module
- Modular Construction

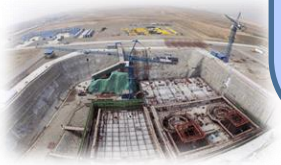
Flexible Application
- Remote regions
- Small grids

Smaller footprint
- Reduced Emergency planning zone

Replacement for aging fossil-fired plants

Potential Hybrid Energy System





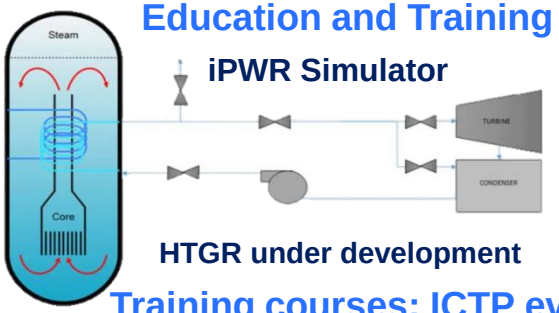
Information Exchange

ARIS database and SMR booklet

Coordinate Research Projects

1. Development of Approaches, Methods and Criteria for Determining Technical Basis for EPZ for SMR Deployment
2. Design and Performance Assessment of Passive Engineered Safety Features in Advanced SMRs.

Education and Training

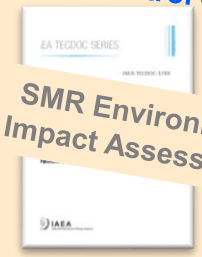


iPWR Simulator

HTGR under development

Training courses; ICTP events

Publications



SMR Instrumentation and Control Systems

Technology Roadmap

SMR and Hybrid Energy Systems

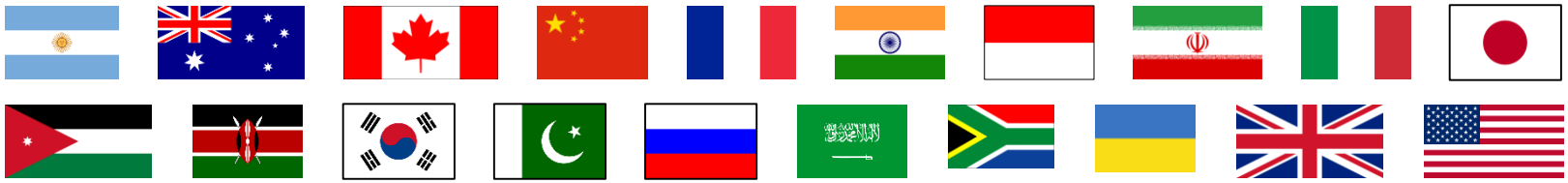
SMR Environment Impact Assessment

Deployment Indicators

Published and Upcoming

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:

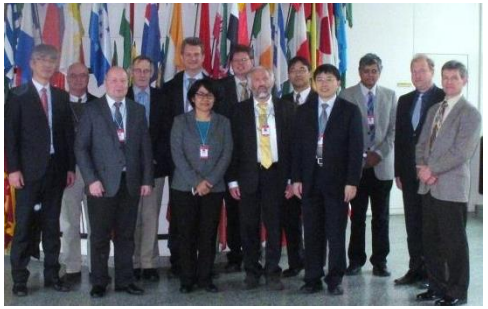


- Three technical subgroups established in 2018 / 2019:
  - **SG-1:** Development of Generic Users Requirements and Criteria (GURC)
  - **SG-2:** Research, Technology Development and Innovation; Codes and Standards
  - **SG-3:** Industrialization, design engineering, testing, manufacturing, supply chain, and construction technology
- TWG also address SMR for Non-Electric Applications and coupling with renewables
- 1st TWG Meeting held on 23 - 26 April 2018 in Vienna
- 2nd Meeting : 8 – 11 July 2019 in Vienna
- 3rd scheduled for 29 June – 2 July 2020 in Vienna

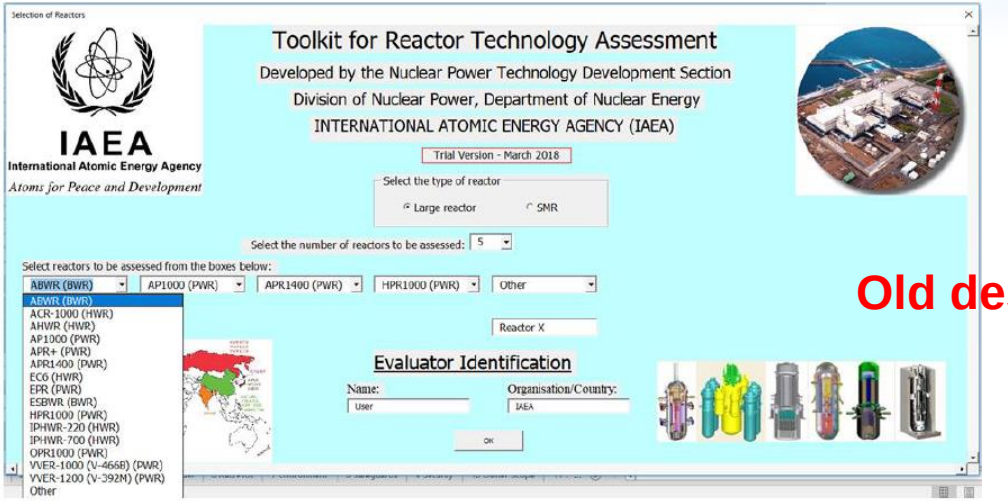
Technical Working Group - GCRs

- GCR-TWG:
  - **Members:** China, France, Germany, Indonesia, Japan, Korea (Rep. of), Netherlands, Poland, Russian Federation, South Africa, Switzerland, Turkey, Ukraine, United Kingdom, United States of America
  - OECD/NEA,
  - European Commission
  - Gen-IV**.**
  - Observer: Singapore

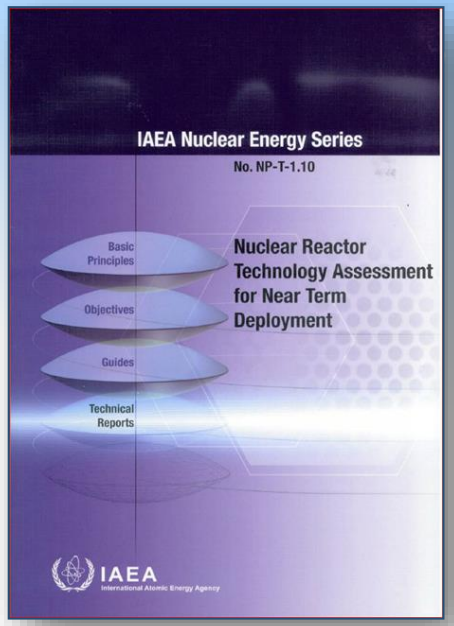
- **Focus mostly on HTGRs**
- **Advisory role on major development areas and IAEA activities**
- Meet every 18 - 24 months
- Next meeting scheduled 11-13 Nov 2019



Reactor Technology Assessment



Old design



15 key RTA Elements

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

New design

IAEA

TOOLKIT FOR REACTOR TECHNOLOGY ASSESSMENT

Developed by the Nuclear Power Technology Development Section

Division of Nuclear Power, Department of Nuclear Energy

INTERNATIONAL ATOMIC ENERGY AGENCY

* Form completed 2019-05-30

EVALUATOR INFORMATION

Name

Organisation/Country

Go Next

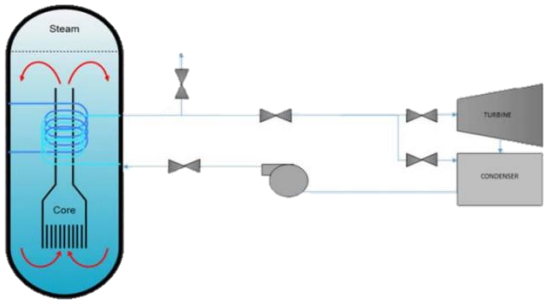
SMR Simulator for Education

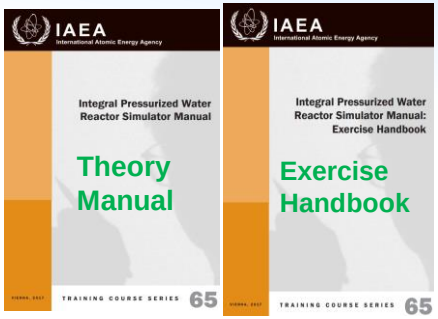
iPWR Simulator, available to download for free

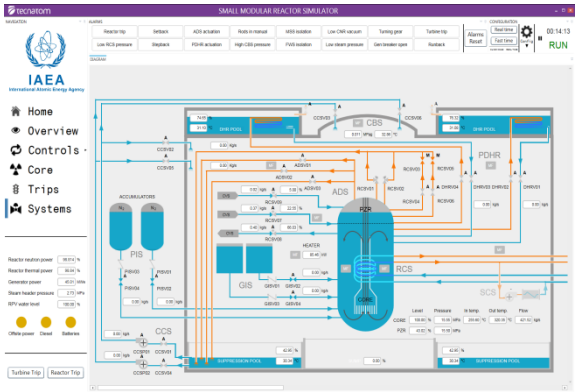
- 150 MWth, integral type PWR, 14 systems including various integrated passive safety systems

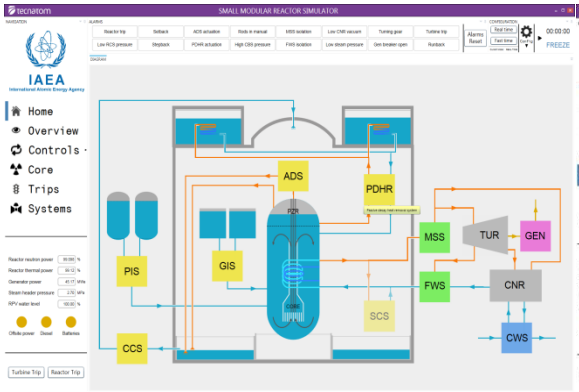
Passive systems

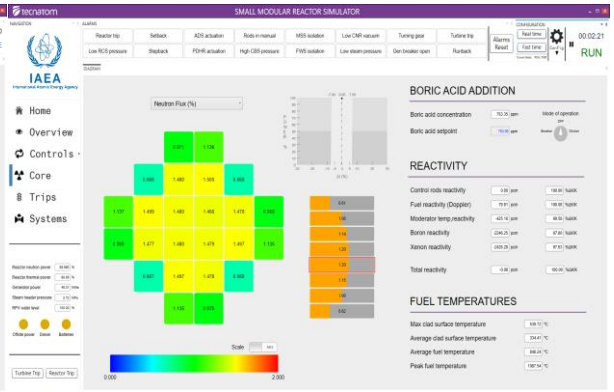
Automatic Depressurisation system (ADS)
Pressure Injection system (PIS)
Gravity Injection system (GIS)
Passive heat removal system (PDHR)











Planned SMR Simulator, advanced and innovative reactors

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

SMR: Ongoing Support to Member States through TC

Ongoing SMR/HTGR Missions

- Indonesia
- Jordan
- Saudi Arabia

Technical Cooperation Project: Europe/Eurasia

- Armenia
- Azerbaijan
- Croatiiaa
- Czechia
- Hungary
- Lithuania
- Poland
- Romania
- Russia
- Slovakia
- Taiikistan
- 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)

Status and major accomplishment in Technology Developer Countries







Countries	Recent Milestone
Argentina	**CAREM25** is in advanced stage of construction. Aiming for fuel loading & start-up commissioning in 2019
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	• 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






Countries	Recent Milestone
Saudi Arabia	• **Vision 2030 → National Transformation Program 2020: Saudi National Atomic Energy Project:** • **K.A.CARE** and **KAERI** completed a PPE to prepare 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 in operation • BAPETEN, the regulatory body has issued a site license • Recent (2019) plan to deploy water cooled SMR in West-Kalimantan
Jordan	• Jordan, Saudi Arabia and Republic of Korea conducted a feasibility study for a deployment of **SMART** in Jordan. • Four other SMR designs also considered and a feasibility studies are being conducted
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** (2018)

Status of SMR pre-licensing in Canada

Vendor	Name / cooling type	(MWe)	Applied for	Review start date	Status
Terrestrial Energy Inc.	IMSR Integral Molten Salt Reactor	200	Phase 1	April 2016	Phase 1 complete
			Phase 2	December 2018	Phase 2 assessment in progress
NuScale Power, LLC	NuScale Integral Pressurized Water Reactor	50	Phase 2*	April 1, 2019	Service agreement signed. Assessment pending
Ultra Safe Nuclear Corporation / Global First Power	MMR-5 and MMR-10 High Temperature Gas	5-10	Phase 1	December 2016	Phase 1 complete
			Phase 2	Pending	PHASE 2 Service Agreement in place – Project start pending
Westinghouse Electric Company, LLC	eVinci Micro Reactor Solid core and heat pipes	up to 25 MWe	Phase 2*	Pending early 2019	Service agreement under development
LeadCold Nuclear Inc.	SEALER Molten Lead	3	Phase 1	January 2017	Phase 1 on hold at vendor's request
Advanced Reactor Concepts Ltd.	ARC-100 Liquid Sodium	100	Phase 1	Fall 2017	Assessment in progress
URENCO	U-Battery High-Temperature Gas	4	Phase 1	To be determined	Service agreement under development
Moltex Energy	Moltex Energy Stable Salt Reactor Molten Salt	300	Series Phase 1 and 2	December 2017	Phase 1 assessment in progress
SMR, LLC. (A Holtec International Company)	SMR-160 Pressurized Light Water	160	Phase 1	July 2018	Assessment in progress
StarCore Nuclear	StarCore Module High-Temperature Gas	10	Series Phase 1 and 2	To be determined	Service agreement under development

First Canadian SMR licence application submitted

- **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**

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First Canadian SMR licence application submitted

02 April 2019

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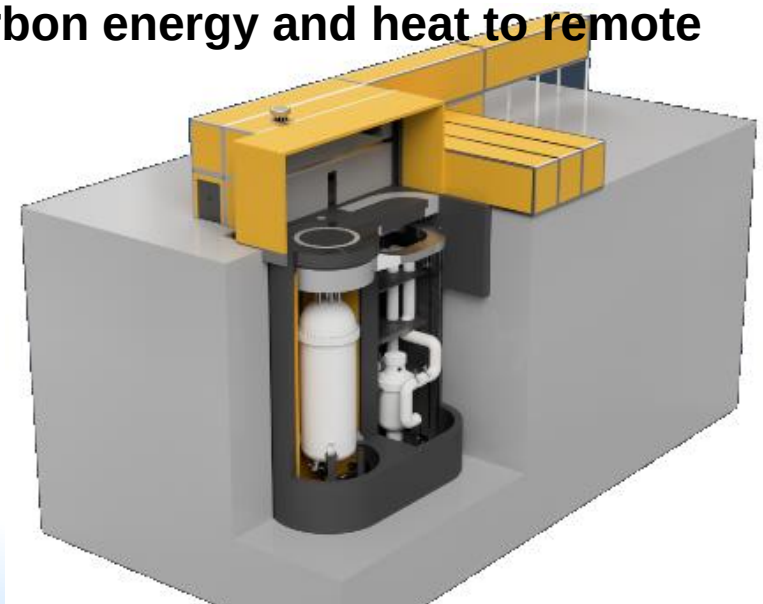
The Canadian Nuclear Safety Commission (CNSC) has received the first licence application for a small modular reactor. The application from Global First Power (GFP), with support from Ontario Power Generation and Ultra Safe Nuclear Corporation (USNC), supports a proposal to deploy a Micro Modular Reactor plant at Chalk River in Ontario.



- The IAEA is acting as the secretariat for the SMR Regulators' Forum
- Established working groups:
  - Graded approach; Defence in Depth; Emergency planning zone
  - Report available at: https://www.iaea.org/topics/small-modular-reactors/smr-regulators-forum
  - Current topics: Licensing issues; Design and Safety; Manufacturing, Commissioning and Operations

Safety of nuclear installations – Regulatory issues

- SMR Regulators' Forum:
  - Pilot Phase (2015-2017) with 3 Working Groups: graded approach; defence in depth and emergency planning arrangements
  - Phase 2 (2018-) with three new Working Groups: licensing; design safety and safety analysis; manufacturing, commissioning and operation
  - Next meeting planned for Q4 2019

- Capacity Building for SMRs (Planned Workshops)
  - Siting and External Hazards Evaluation
  - Design safety and safety assessment
  - Principles for Emergency Preparedness & Response
  - Regulatory framework and licensing issues

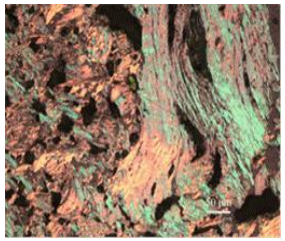
Coordinated research projects

- Projects and status

HTGRs – Coordinated Research Projects

Completed 2014 CRP on Improving the Understanding of Irradiation-Creep Behaviour in Nuclear Graphite: 2x TECDOCS under preparation

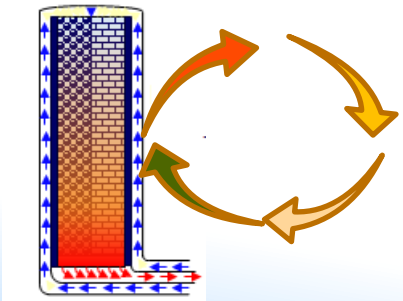
- Part 1: Models and Mechanisms
- Part 2: Recent Developments



To determine the uncertainty in HTGR calculations at all stages of coupled reactor physics, thermal-hydraulics and depletion calculations - Completed 2019

CRP on HTGR Uncertainty in Analysis

HTGRs applications for energy neutral sustainable comprehensive extraction and mineral products development –completed 2019



Use process heat
Extract U/Th with products i.e. cleaner fertilizer
U / Th content and extraction studies

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. Development of Approaches, Methods and Criteria for Determining Technical Basis for EPZ for SMR Deployment
4. Design and Performance Assessment of Passive Engineered Safety Features in Advanced SMRs.
5. HTGRs applications for energy neutral sustainable comprehensive extraction and mineral products development (T11006 - with NEFW-NFCM)

NEW CRPs proposed:

- New coordinated research project on 'Technologies to enhance the competitiveness and early deployment of SMRs and HTRs' to start in 2020.

CRP I1026 on Modular High Temperature Gas cooled Reactor Safety Design – Till Dec 2018

- Investigate modular HTGR safety design criteria to assure that an acceptably broad spectrum of design and beyond design basis events are addressed in the international design and development community
- **Approach 1 limits scope to qualitative, functional statements of how top requirements are to be met for only SSCs that are safety-related for public safety with examples from conceptual design of MHTGR (steam cycle for electricity)**
- **Approach 2 study the IAEA SSR-2/1 SDC for applicability / interpretation for modular HTGRs**

10 participating organizations from 9 member states: China, Germany , Indonesia, Kazakhstan, Korea (Republic of), Japan , UK, Ukraine, USA

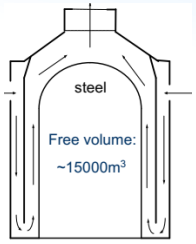
- 4th RCM 11 – 14 June 2018

Planned outcomes:

- NE series report: Modular High Temperature Gas-cooled Reactor Safety Design Criteria
- TECDOC: Modular High Temperature Gas-cooled Reactor Safety Design Methodology and Implementation Examples

CRP I32010 Passive Engineered Safety Features in iPWRs

- Develop an approach for
  - designing passive engineered safety features for water-cooled SMRs and
  - offering good practices for assessing their performance and reliability
  - verification & validation methodologies

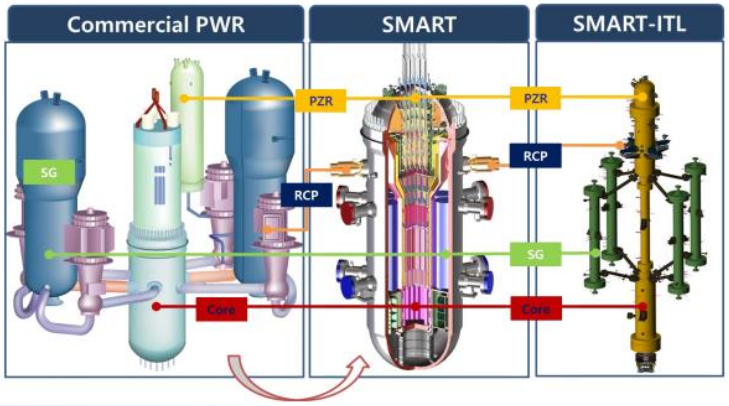


- Focus groups:
  - Passive Safety System Design and Technology Development
  - Approaches and Methods for Functional Reliability Assessment of Passive Systems
  - Experiments, Analysis and V&V

- 3 Year project from July 2017 until July 2020
  - Argentina, Canada, China, Egypt, India, Indonesia, Italy, Republic of Korea, Lithuania, Pakistan

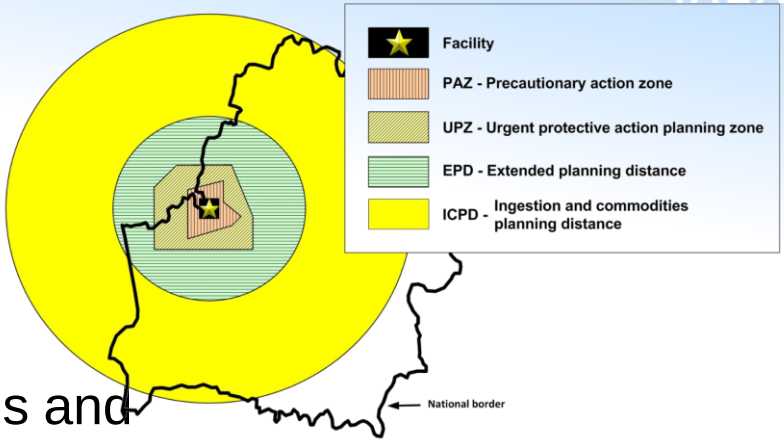
- RCMs:
  - RCM1: 30 Oct – 3 Nov 2017
  - RCM2: 7 – 10 May 2018
  - RCM3: 3 - 6 September 2019, KAERI

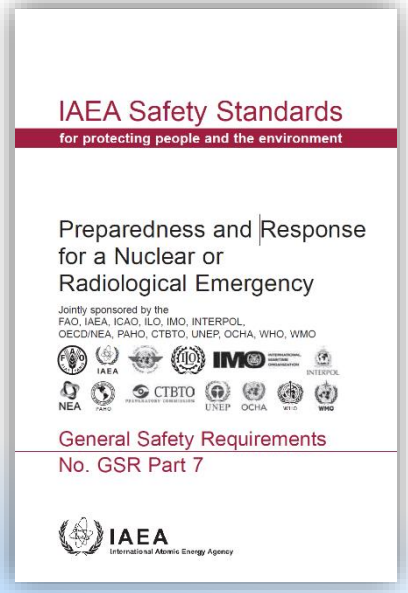
- TECDOC draft under development



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.





- 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)
- Several advanced reactor designs and experiments (including HTGRs)
- RCM-1 took place May 14-17 2018
- RCM-2 took place May 27-31 2019 in Beijing, China
- RCM-3 planned for May 26-29 2020 in Vienna

Progress made in applying a graded approach

- Nuclear Regulatory Commission staff agreed with the Tennessee Valley Authority that scalable emergency planning zones (EPZs) for small modular reactors are feasible
- …The preliminary finding

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US regulators discuss smaller SMR emergency zones

28 August 2018

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CLARIFICATION: NRC staff have concluded the TVA methodology can be used in the future to determine if a reduced emergency planning zones is justified, and has not made a decision on EPZ criteria for small modular reactors.

The US Nuclear Regulatory Commission (NRC) has concluded that Tennessee Valley Authority's (TVA's) methodology can be used in the future to determine if a reduced emergency planning zone is justified for small modular reactors, a spokesman for the Commission told *World Nuclear News* today. It has not yet agreed that an EPZ around small modular reactors can be scaled to reflect their reduced risks rather than the mandatory ten-mile EPZ required for the USA's current light-water reactor fleet.

2020: Technologies to enhance the competitiveness and early deployment of SMRs and HTRs

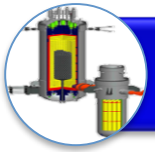
Project number	1000153
Project name	1.1.5.002 Technology development for small and medium-sized or modular reactors
Task Number	2020.09 I3_HTR Applic
Task Type:	CR-Coordinated Research Project (CRP)
Task Short Name	CRP HTGR_Applic
Task Long Name	Technologies to enhance the competitiveness and early deployment of SMRs and HTRs

- 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 needs 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

Project number	1000153
Project name	1.1.5.002 Technology development for small and medium-sized or modular reactors
Task Number	2020.10 I3_SMR_Validat
Task Type:	CR-Coordinated Research Project (CRP)
Task Short Name	CRP SMR Valid.NearT
Task Long Name	CRP on the experimental facility and prototype testing needs for validation and to enhance near-term SMR deployment

- 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



Recent publications

- Published
- Planned

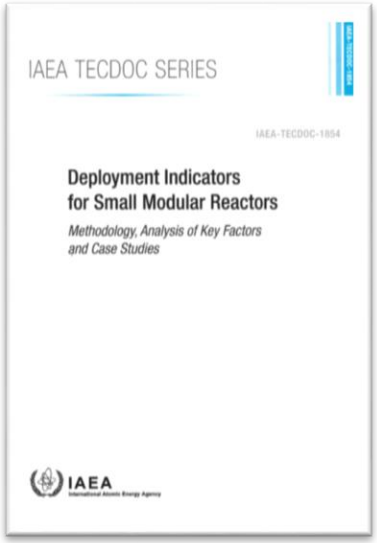
IAEA-TECDOC-1854 Deployment Indicators of SMRs

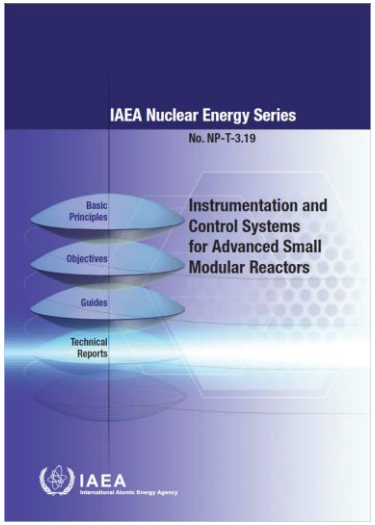
SMR Deployment Indicators are evaluated in following categories

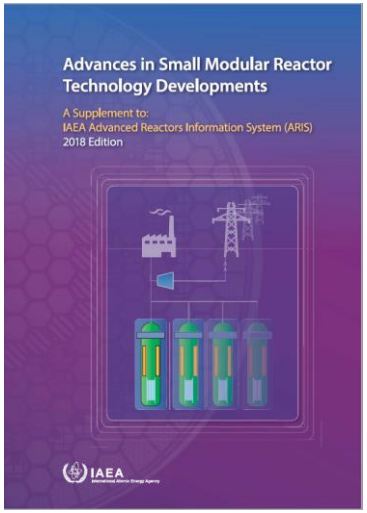
National Energy Demand	*SMR Energy Demand*	*Financial/ Economic Sufficiency*	*Physical Infrastructure Sufficiency*	*Climate Change Motivation*	*Energy Security Motivation*
Growth of Economic Activity (GDP GWTH)	Dispersed Energy (RURAL)	Ability to Support New Investments (GDP/PC-GDP)	Electric Grid Capacity (GRID)	Reduce CO_2 Emissions per Capita (CO2)	Reduce Energy Imports (ENG IMP)
Growth Rate of Primary Energy Consumption (GRPEC)	Co-Generation (DESAL/DH)	Openness to International Trade (FDI/TRADE)	Infrastructure Conditions (INFRA)	Reduce Fossil Fuel-Energy Consumption (FOSSFUEL/OGC)	Use Domestic Uranium Resources (URAN)
Per Capita Energy Consumption (PC-EC)	Energy Intensive Industries (EII)	Fitness for Investment (CREDIT)	Land Availability (LAND)	Achieve NDC Carbon Reduction Goals (NDC)	Balance Intermittent Renewables (RES)

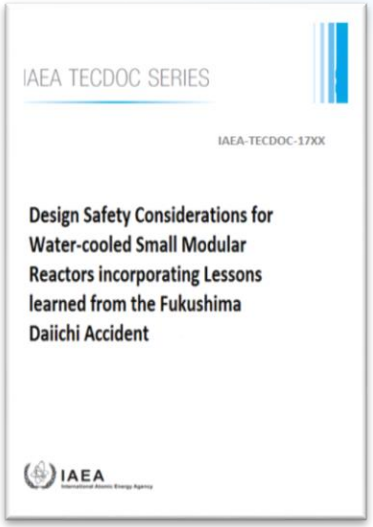
Published in September 2018

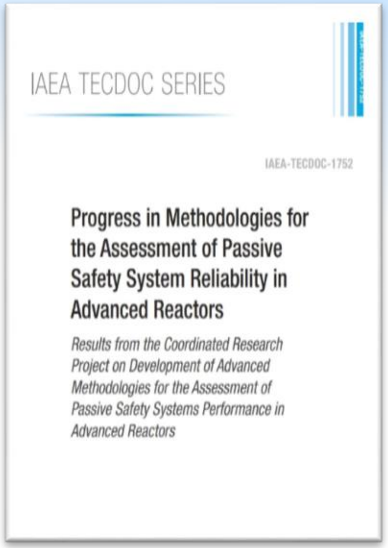
Recent Publications and Forthcoming Ones







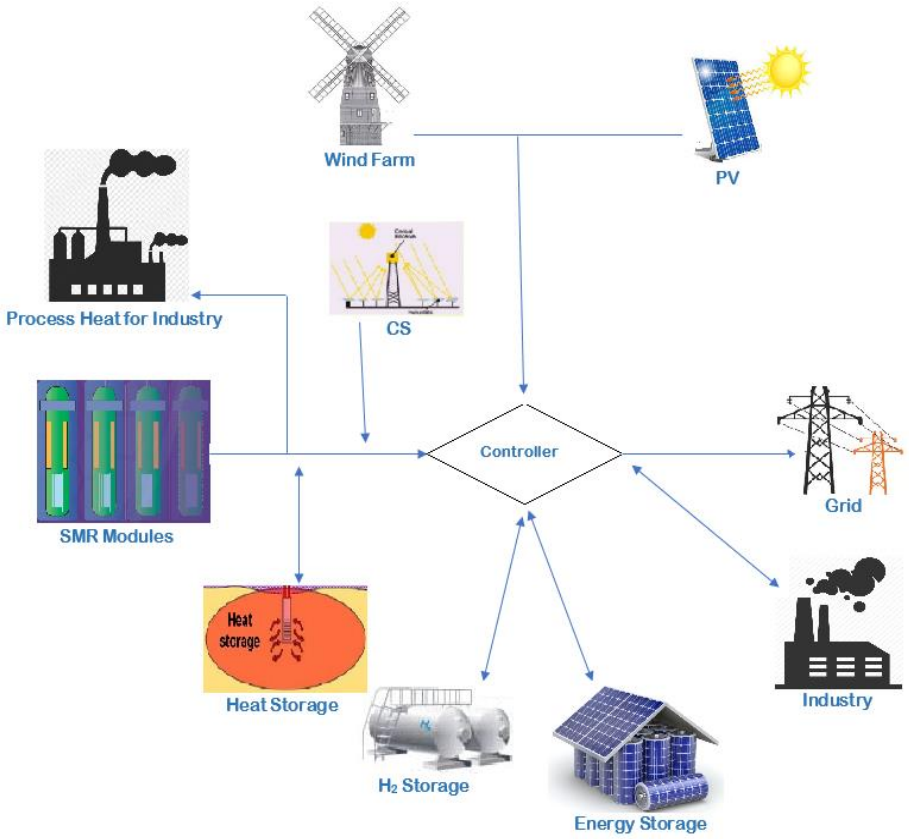




- NES **Technology Roadmap** for Small Modul Reactor Deployment
- TECDOC: Status of Approaches for Environmental Impact Assessment for **SMR** Deployment
- TECDOC: Options to Enhance Energy Supply Security using **Hybrid Energy Systems**

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

- Meetings
- Workshops
- Conferences

Meetings - 2019

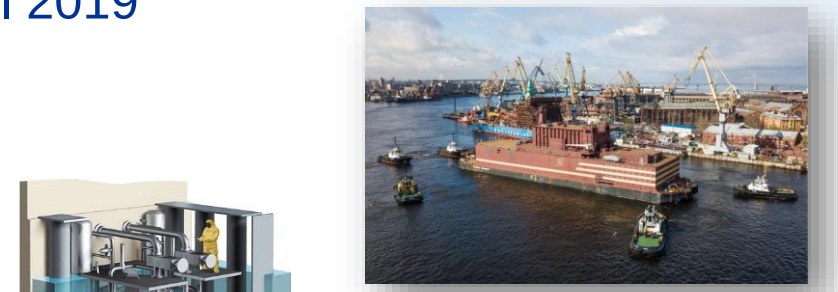
- Technical Meeting on Benefits and Challenges of Fast Reactors of SMR Type; 24-27 September 2019.
- Technical Meeting of the Technical Working Group on Gas Cooled Reactors (TWG-GCR); 11 – 13 Nov 2019
- Technical Meeting on Technologies to Enhance the Competitiveness and Early Deployment of SMRs and 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

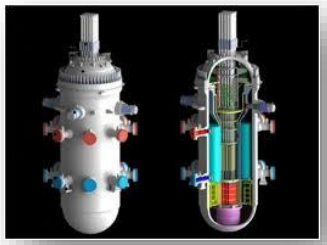
INPRO Dialogue Forum 17 in Coordination with NPTDS

https://nucleus.iaea.org/sites/INPRO/Pages/df-17.aspx

"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

Current INPRO Study on TNPPs

- INPRO Steering Committee supported start of Collaborative Project "**Case Study for Deployment of a Factory Fuelled SMR**" from 2015
- Objective is to examine, in detail, **legal and institutional issues** for export deployment of a **TNPP with a factory fuelled and tested reactor**
  - Current study is based on the conclusion from early study on TNPP that for factory fuelled reactors, there are obvious 'gaps' and insufficient coverage
- Participating Member States: Armenia, China, France, Finland, Indonesia, Romania, Russian Federation, USA
- Output: a TECDOC series publication

Topics covered in draft TECDOC

- **Specific issues on legislation**
  - Maritime law
  - Nuclear liability and interaction between states
  - Transportable Nuclear Module relocation
- **Specific issues on nuclear safety and protection of the environment**
  - Applicability of the existing global nuclear safety regime
  - Responsibilities of the stakeholders
  - Analysis of specific features at various lifecycle stages
  - Environmental impact issues
  - Emergency planning issues
- **Specific issues on safeguards**
- **Nuclear security considerations**
- **Specific issues on licensing process**
- **Specific issues on staffing and training**

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

Applications for financial support closed 28 JULY 2019

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

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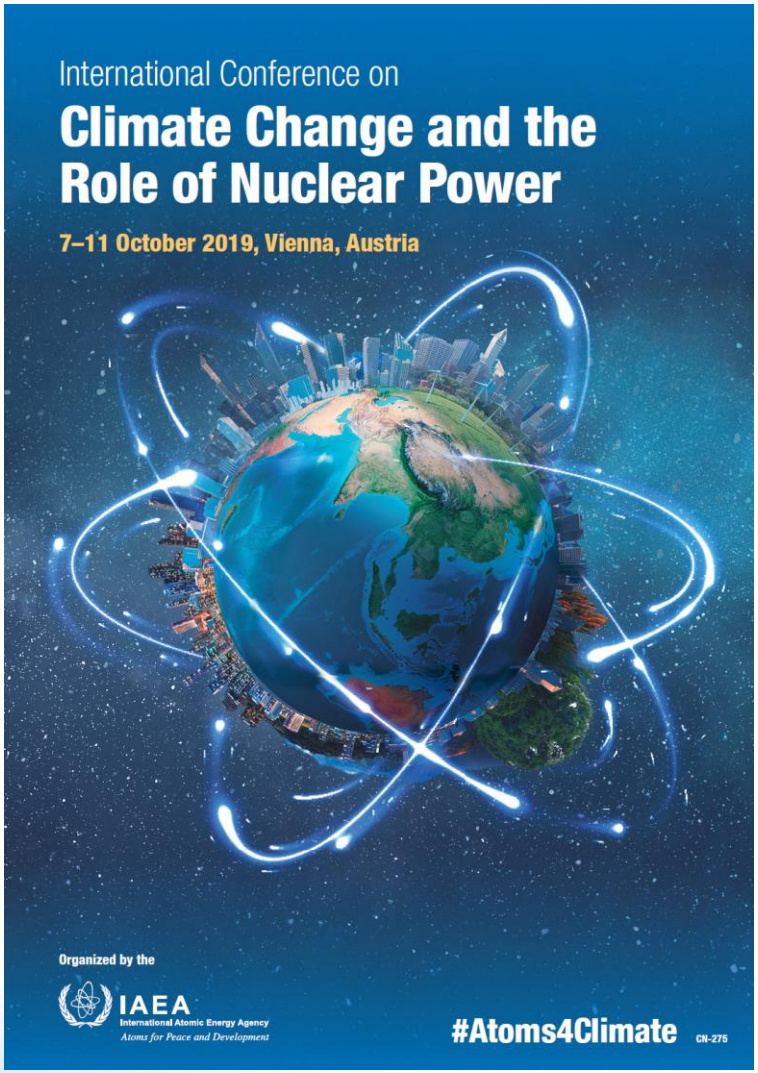
Joint ICTP-IAEA Workshop on Physics and Technology of Innovative High Temperature Nuclear Energy Systems | (smr 3281)

Starts 14 Oct 2019
Ends 18 Oct 2019
Central European Time

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

Organizers

Ibrahim Khamis (IAEA), Frederik Reitsma (IAEA), Local Organiser: Nicola Seriani



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Proposed meetings 2020

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

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Atoms for Peace and Development

Thank you!

For inquiries on SMR, please contact:

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Team Leader: SMR Technology Development

IAEA Nuclear Power Technology Development Section

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