IAEA
International Atomic Energy Agency

"Atoms for Peace and Development"

FR22: IAEA Conference on
Fast Reactors and Related Fuel Cycles
19 – 22 April 2022
Vienna, IAEA

IAEA Activities on Fast Reactors Technologies and Related Fuel Cycles

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https://www.iaea.org/topics/fast-reactors

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Fast Reactors and Fuel Cycles

- Long term development of sustainable nuclear power will require fast reactors that can utilize almost all natural uranium
  - Only ~1% natural uranium is used in current fleet water cooled reactors
- Sodium cooled fast reactors (SFR) is a mature technology
  - First reactor that generated electricity in 1951 was EBR-1 (experimental breeder reactor) cooled by liquid metal (NaK allow)
  - Several SFRs are operating and under construction and commissioning
  - Sodium brings main serious challenge: active chemical reaction with water and air; requires intermediate circuit ==> expensive
  - New innovative systems, NATRIUM: SFR integrated with molten salt storage
- Several new technologies are under development
  - Heavy liquid metal coolants (lead or lead-bismuth) (BREST-300 is under construction in Russia, ALFRED is under development in EU)
  - Gas and molten salt fast reactors

IAEA DG Grossi attends online pouring of "first concrete" to Gen-IV BREST-300 (2021)

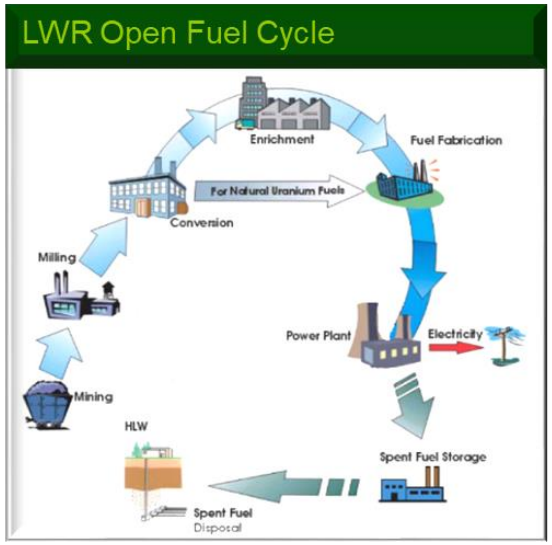
China builds 2 units of CFR-600

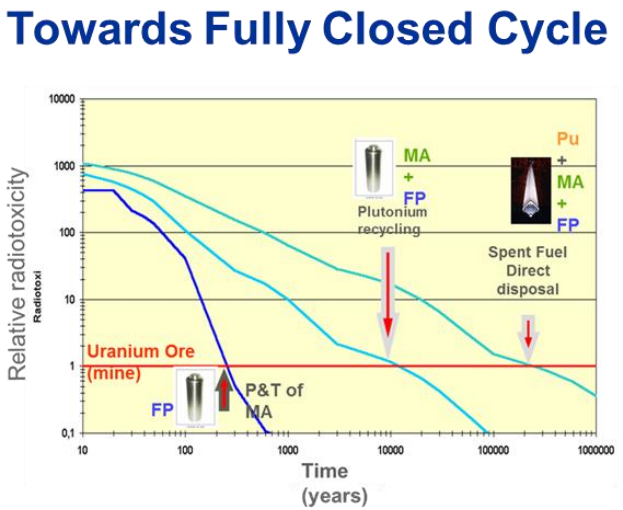
Bill Gates at TerraPower demonstrates a mock-up of sodium cooled subassembly

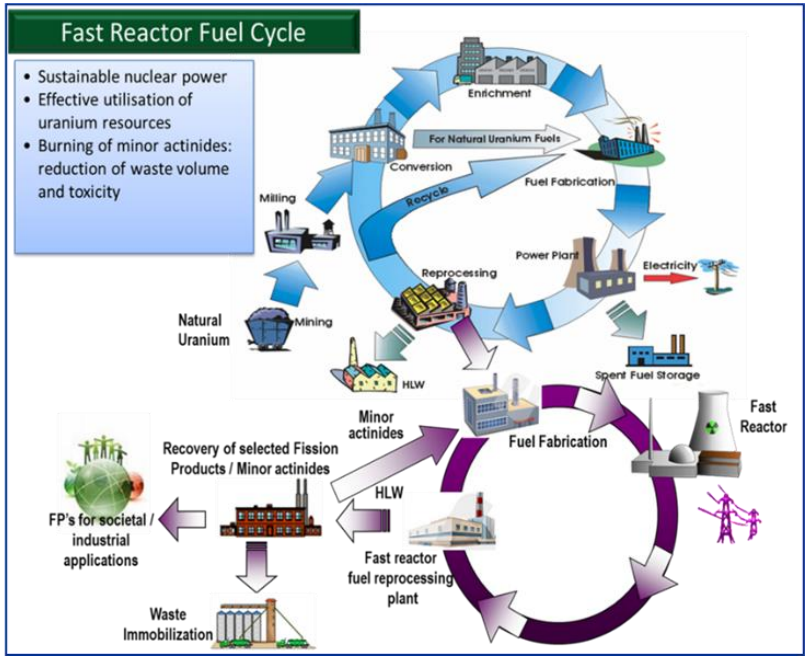
Towards Advanced Fuel Cycle Options

- Natural resources preservation
- Minimizing the burden of waste to be disposed of (reducing footprint of final repository)
- Economically viable fuel cycles through recycling valuable materials
- Enhance safety and security
- Keeping flexibility
- …

* From IAEA e-Learning Module on Spent Fuel Management Course: Course on Spent Fuel (iaea.org)







IAEA Technical Working Groups (TWG) on Fast Reactors and Related Fuels and Fuel Cycles

- **Fast Reactors (TWG-FR)**
  - *Design and technologies for current, evolutionary and innovative fast neutron reactors*
  - *Economics, performance and engineering systems safety for current and advanced fast neutron reactors*
  - *Advances in national programmes*
- **Nuclear Fuel Cycle Options and Spent Fuel Management (TWG-NFCO)**
  - *Nuclear fuel cycle options with an emphasis on spent fuel management (storage and reprocessing & recycling)*
  - *Policies and strategies for managing the backend of the fuel cycle*
  - *Innovative fuel cycles (multirecycling, MAs management and P&T)*
  - *Management of nuclear materials*
  - *Gives duel recognition to all relevant aspects(safety, economy, health, environmental implications and non-proliferation)*
- **Fuel Performance and Technology (TWG-FPT)**
  - *Status and trends in nuclear power reactor fuel performance and technology*
  - *Nuclear core materials research and development, fuel design manufacturing and utilization, coolant chemistry, fuel performance analysis and quality assurance issues*
  - *Gives due recognition to all relevant aspects (safety, economy, management systems, nuclear science and NPP operations)*

Functions of Technical Working Groups:

- *To provide advice to DDG-NE on specific topics of relevance to the IAEA's programmatic activities;*
- *To share information and knowledge on national and international programmes;*
- *To contribute to the development and/or review of selected IAEA publications, assess existing gaps and advise on the preparation of new publications or e-learning materials;*
- *Upon request, to present to the Standing Advisory Group on Nuclear Energy(SAGNE) the key findings of the TWG meeting; and*
- *To share experience and advice on increasing the participation of young professionals and improving the gender balance in the nuclear sector.*

They are composed by 20 Member States and 3 International Organizations

55th TWG-FR Meeting: **23-27 May 2022**

20th TWG-NFCO Meeting: **10-12 May 2022**

20th TWG-FPT Meeting: **5-7 April 2022**

IAEA Coordinated Research Projects on Fast Reactors Technology

The IAEA encourages and assists research on and development and practical use of atomic energy and its applications for peaceful purposes throughout the world. It brings together research institutions from its developing and developed Member States to collaborate on research projects of common interest, so-called **Coordinated Research Projects** (**CRPs**).

CRP completed in last decade

- **BN-600** MOX Core Benchmark
- **PHENIX** – EOL Tests
- **MONJU** – Na Natural Convection
- Analytical and Experimental Benchmark Analysis of **ADS**
- **EBR-II** Shutdown Heat Removal Tests

CRPs on Fast Reactors Technology

On-going CRPs

- **PSFR Source Term** – Radioactive Release Under Severe Accident Conditions
- Neutronics Benchmark of **CEFR** Start-Up Tests (29 participants)
- Benchmark Analysis of **FFTF** Loss of Flow Without Scram Test (25 participants)
- **NAPRO** – Na Properties and Safe Operations of Exp. Facilities
  Ended in Sept 2018
  2 TECDOCs in Publishing

New Proposals

- Total Instantaneous Blockage of SFR Fuel Assembly
- Simulation of **CLEAR-S** Loss-of-Flow Experiment
- Benchmark Analysis of **STELLA-2** LOHS/LOF Tests
- Natural Circulation in LBE Sub/Assembly: **NACIE** Tests
- **PLANDTL**: Decay Heat Removal Thermal Hydraulics Tests

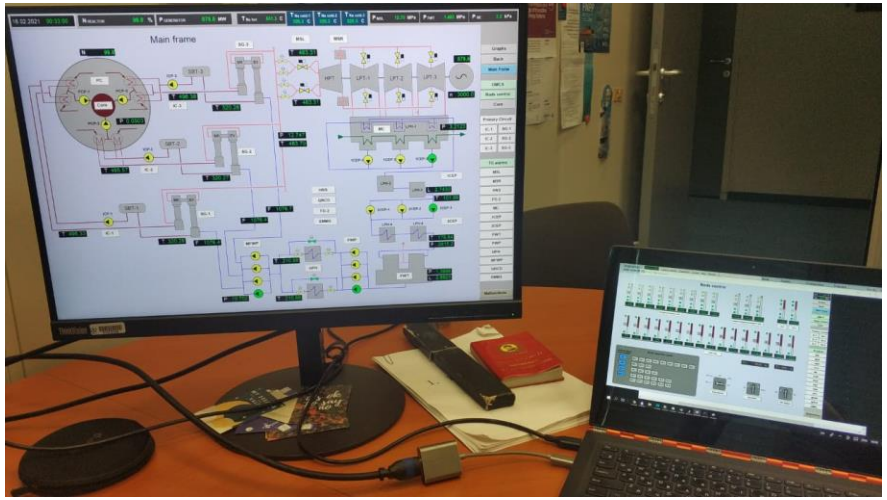
Training, Education, and Engagement on Fast Reactor Technologies

ICTP-IAEA Workshops on Innovative Nuclear Energy Systems

- In **2016** and in August **2018** Trieste, Italy
- Contributed by NPTDS, INPRO, GIF, and other external experts
- Next Workshop: Dec 2022

SFR Educational Simulator

- Pool type sodium cooled fast reactor simulator for education and training
- Exercise and Training material in Development
- February 2021: Factory Acceptance Tests
- January 2022: Site Acceptance Tests
- 2022: Distribution to the Member States



Regional Workshop

- Advances in the Modelling and Simulation of Thermal Hydraulics in Liquid Metal Cooled Fast Reactors, India
- November 2022

Training Series Doc: Neutronic Start-Up Test

- Adapting the outputs of CEFR CRP as guided exercise
- 2022

Fast Reactors Safety: Joint GIF-IAEA Workshops on Safety of LMFRs

A decade of cooperation

1st : June 2010
2nd : Dec 2011
3rd : Feb. 2013
4th : June 2014
5th : June 2015
6th : Nov. 2016

7th Joint GIF-IAEA Workshop on LMFR Safety

March 2018

- Final Review of GIF Report on "Safety Design Guidelines on Safety Approach & Design Conditions for GEN-IV SFRs"

8th GIF-IAEA Workshop on LMFR Safety

20-22 March 2019

- Discussion of GIF Report on "Safety Design Guidelines on Structures, Systems and Components for Gen-IV SFRs"

9th GIF-IAEA Workshop on LMFR Safety

30 March – 1 April 2021

- Review of GIF Report on "Safety Design Guidelines on Structures, Systems and Components for Gen-IV SFRs"

10th GIF-IAEA Workshop on LMFR Safety

June 2022

Organized by NSNI

Review of GIF Report on
"Safety Design Criteria for Gen-IV LFRs"

IAEA on-going activities on Fast Reactor Fuel Development

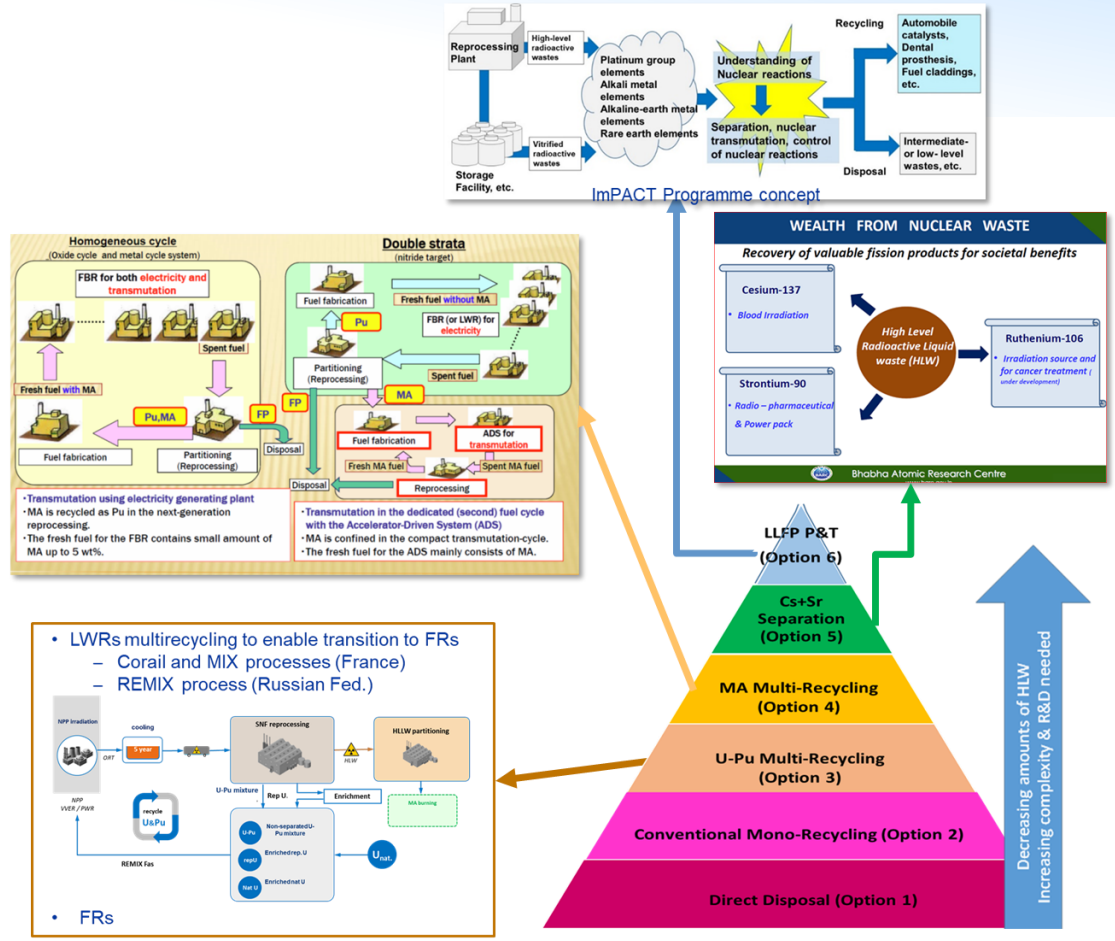
- Development of IAEA publications
  - IAEA Nuclear Energy Series on *"Nuclear Fuel Technologies for Liquid Metal Cooled Fast Reactors* (LMFRs)": a state-of-the-art report that can be used by Member States as a global reference to understand and address the factors affecting the design, fabrication, and in-pile behaviour of nuclear fuels (MOX, Metal, Nitrides) for fast reactors, including SMRs
  - IAEA TECDOC on "*Mixed Oxide Fuels Design, Operations and Management":* a state-of-the-art report with information on the design, fabrication and operation of U-Pu oxide fuels (feedback experience on MOX fuel utilization)
- Development of IAEA e-learning on "Fast reactor fuels"
- Coordinating research activities
  - IAEA Coordinated Research Project T12031 (2020-2024) on *"Fuel Materials for Fast Reactors",* coordinating Member States' programmes on fuel (MOX and Metal) and cladding materials' performance assessment for the sodium-cooled fast reactor technology, in accordance with Gen-IV requirements, through enhancing fuel performance codes

Fast reactor fuel pins, $(U,Pu)O_2$ in Steel cladding, helical spacer wire (Na coolant)

IAEA on-going activities on Advanced Fuel Cycles

Development of IAEA publications

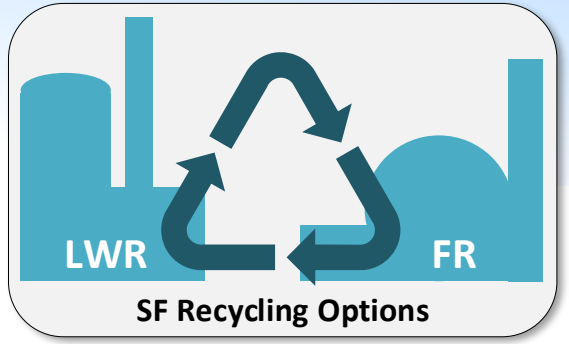
- **IAEA Nuclear Energy Series on** *"Existing and Advanced Nuclear Fuel Cycle Technical Options for Waste Burden Minimization"*
- **IAEA-TECDOC on** *"A Collection of Some Member States' Environmental Impact Studies of Existing and Future Spent Fuel Management Options on Waste Minimization"*
- **IAEA-TECDOC on** *"Spent Fuel Management in the Longer Term (National Perspectives)*
- **IAEA Nuclear Energy Series on** *"Integrated Approaches for Managing the Backend of Fuel Cycle Options"*



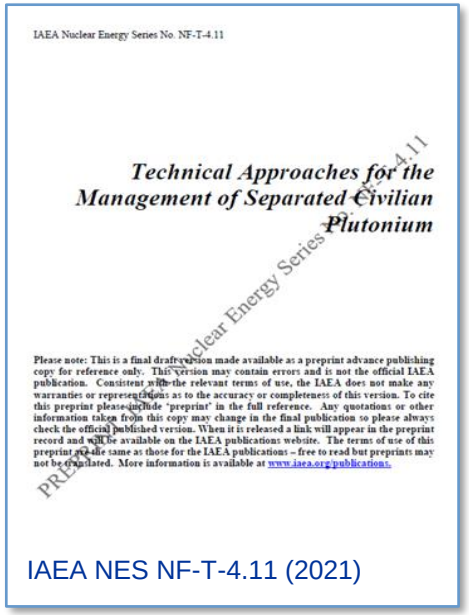
IAEA on-going activities on Advanced Fuel Cycles

Development of IAEA e-learning on Spent Fuel Recycling

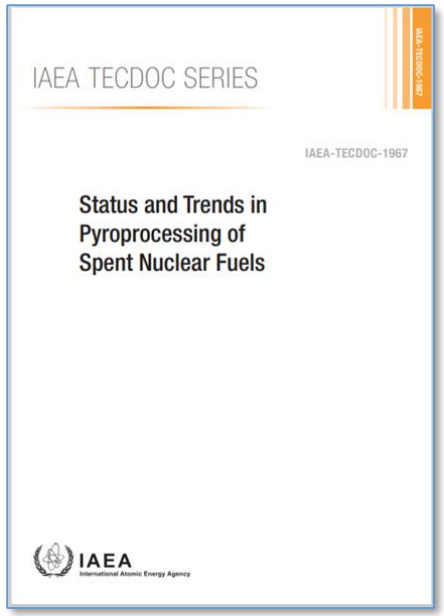
as part of the IAEA e-learning Course on Spent Fuel Management

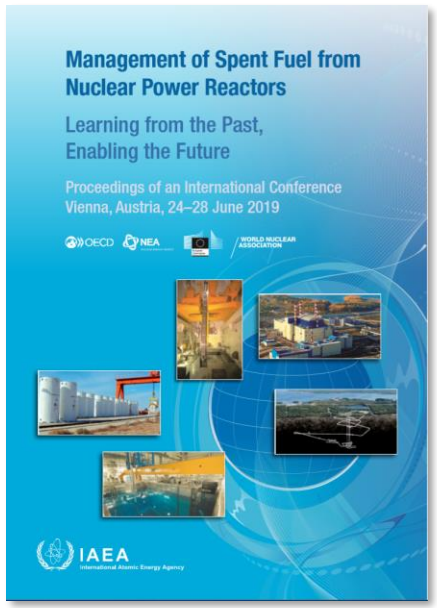


Recent IAEA publications and Webinars



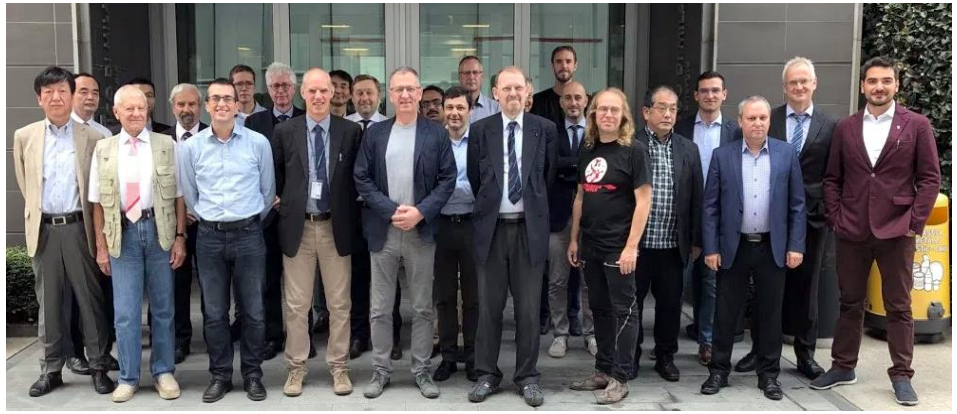
IAEA NES NF-T-4.11 (2021)





Technical Meetings on Fast SMRs

- Technical Meeting on Benefits and Challenges of Fast SMRs, September 2019, Milan, Hosted by CIRTEN (*Consortium of Italian Nuclear Universities*)



TECDOC Proceedings published in August 2021

- Technical Meeting on the Design, Fabrication and Irradiation Behaviour of SMRs Fuels, 18-22 October 2021, Vienna (*TECDOC under preparation*)

Coming Soon:

- TM on Backend Technological Options for SMRs Fuel Cycles, **20-23 September, 2022, Vienna**

CIRTEN

Consortium of Italian Nuclear Universities

Thanks to advanced coolants, Fast SMRs can be safer and of simplified design

BUT:

- Fast construction (in-factory) is required to win economic competition;
- Extended R&D are needed to fit technological gaps
- LFRs require more R&D to prove material compatibility and develop new materials
- Licensing challenges

INPRO: Analysis and Assessment - Nuclear Energy System Sustainability

Task 1: Global Scenarios

Task 2: Innovations

Task 3: Sustainability Assessment and Strategies

Task 4: Dialogue & Outreach

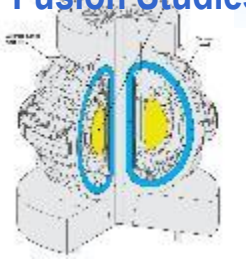
TOOLS / SERVICES

ASENES

Scenario modelling and analysis	Economic analysis and evaluation of Nuclear Energy System (NES)	Comparative evaluation of NESs and scenario options	Road mapping towards enhanced NE sustainability
MESSAGE-NES	NEST	KIND-ET	ROADMAPS-ET

Transportable NPP
Akademik Lomonosov

Fusion Studies

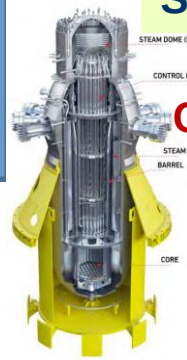


IAEA-TECDOC-1575 Rev. 1

Guidance for the Application of an Assessment Methodology for Innovative Nuclear Energy Systems

INPRO Manual — Overview of the Methodology

SMR NESA



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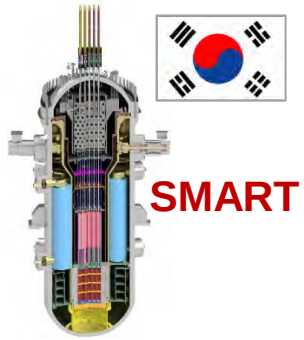


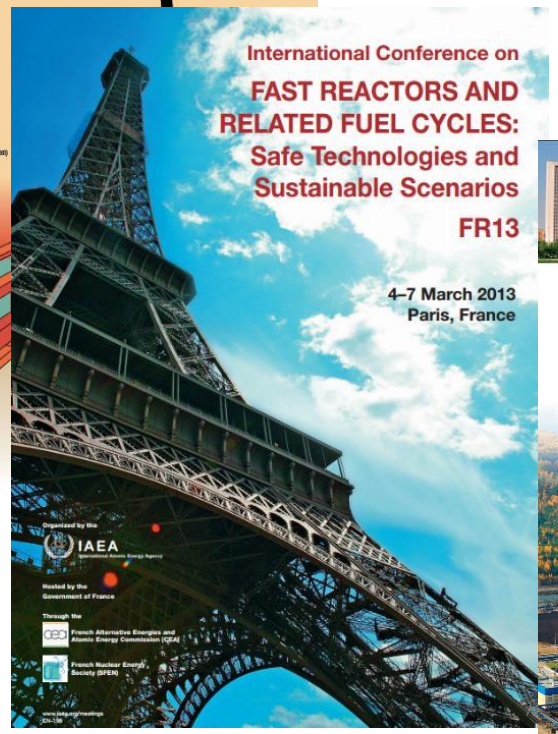
SMART

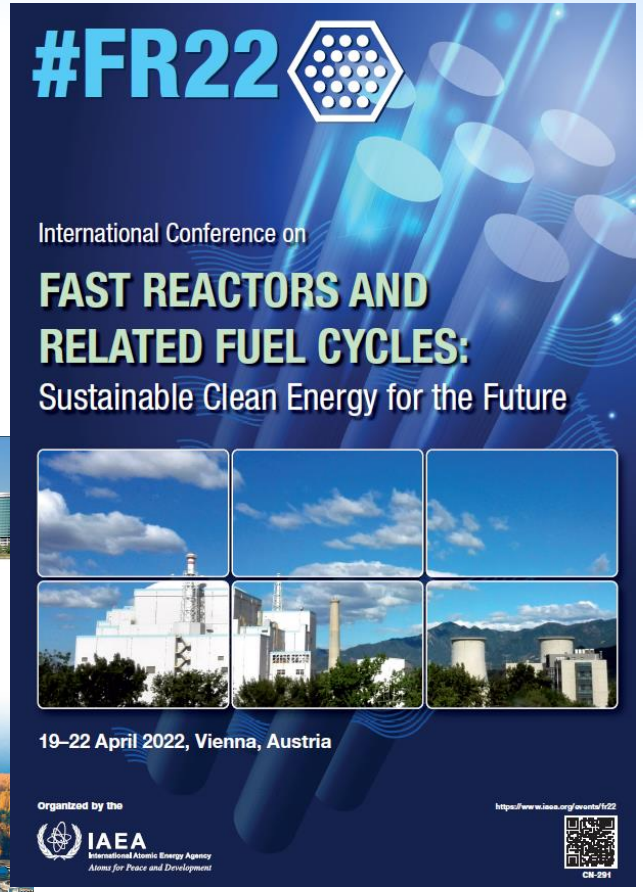
RITM-200M

18th and 19th Dialogue Forums 2021

*** * 20th * ***
Dialogue Forum
NOV 2022
USA

IAEA Conferences on Fast Reactors and Related Fuel Cycles: 2009, 2013, 2017, 2022, 2025?





FR22:
460 Participants
49 Member States
3 Intl. Organizations
(to be updated)

Organized jointly by
Divisions of Nuclear Power and
Nuclear Fuel Cycle and Waste Technology
of IAEA Department of Nuclear Energy

IAEA
International Atomic Energy Agency

Thank You!

FR22

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TM on Benefits and Challenges of Fast SMRs

September 2019, Milan, Hosted by CIRTEN: Consortium of Italian Nuclear Universities

Country	Participants /Papers
Belgium	4/1
China	2/2
France	1/1
Germany	2/0
India	1/1
Italy	13/5
Japan	3/2
Korea, Rep. of	2/3
Luxembourg	1/1
Netherlands	1/1
Russia	3/2
Slovakia	1/0
Switzerland	1/1
Sweden	1/1
USA	1/1
EC/JRC	3/1
Total: 16	**40/23**

Six Technical Sessions:

- Sodium Cooled Fast SMRs
- Heavy Liquid Metal Cooled Fast SMRs
- Safety Investigations
- Technology and Research in Support of Fast SMRs

Three Group Discussions:

- In-factory construction
- Benefits of Fast SMRs including market needs
- Technological Challenges

TECDOC Proceedings published in August 2021

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