Ongoing activities on Partitioning and Transmutation at the IAEA

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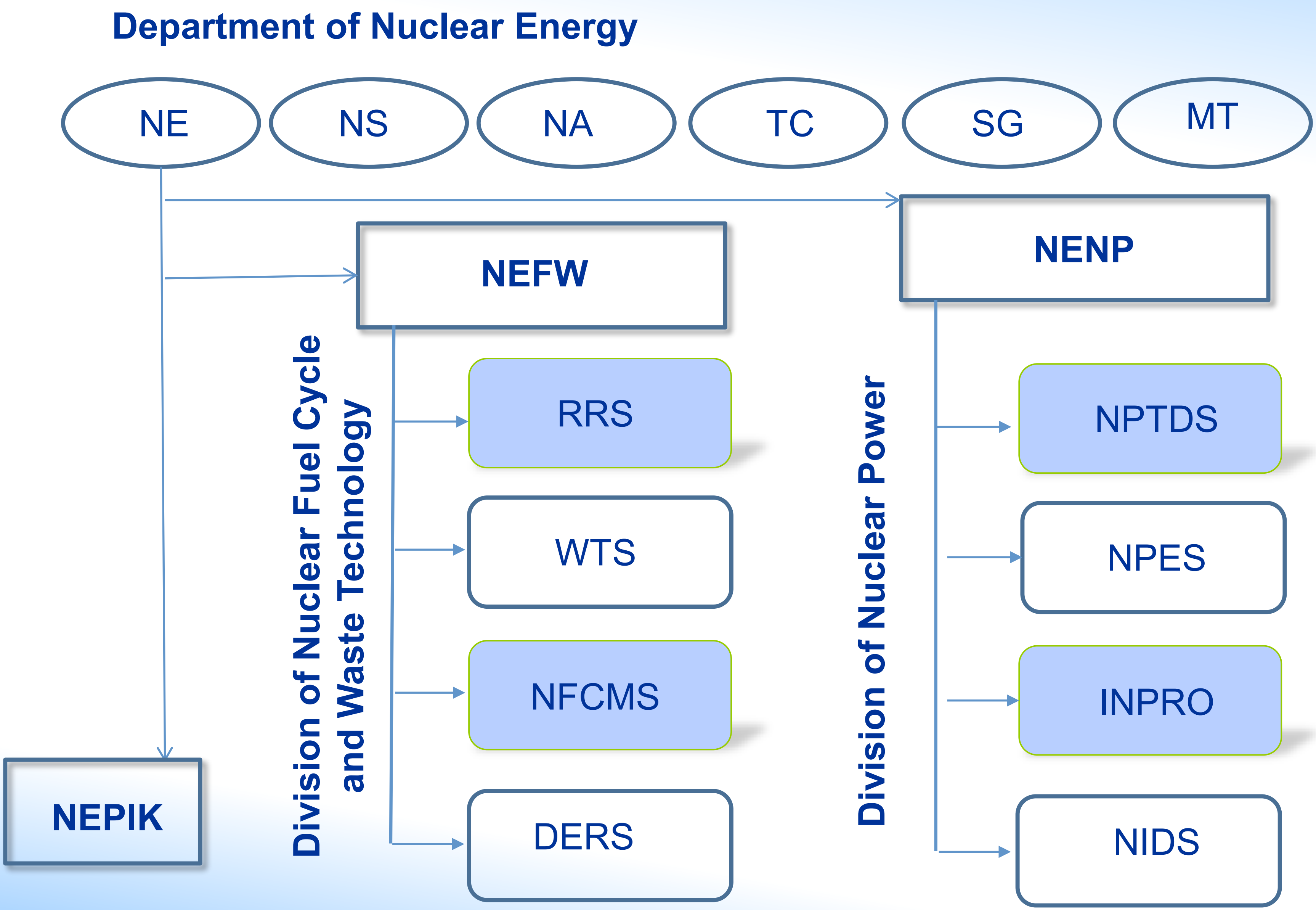
GENIORS Topical Day, 25th October 2015, Antwerp

Outlook

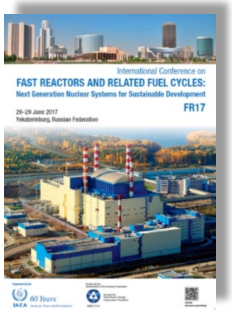
- IAEA
  - Organization, role and governance/advisory boards
- Activities on Advanced Reactors
  - Fast reactors, FR-17, ADS, …
- Activities on Advanced Fuels
  - Coordinated Research Projects (CRPs)
- Activities on Advanced Fuel Cycles
  - CRP on ADS, INPRO Project
- IAEA Databases

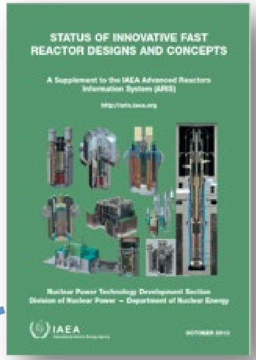
IAEA's organizational chart



IAEA's role

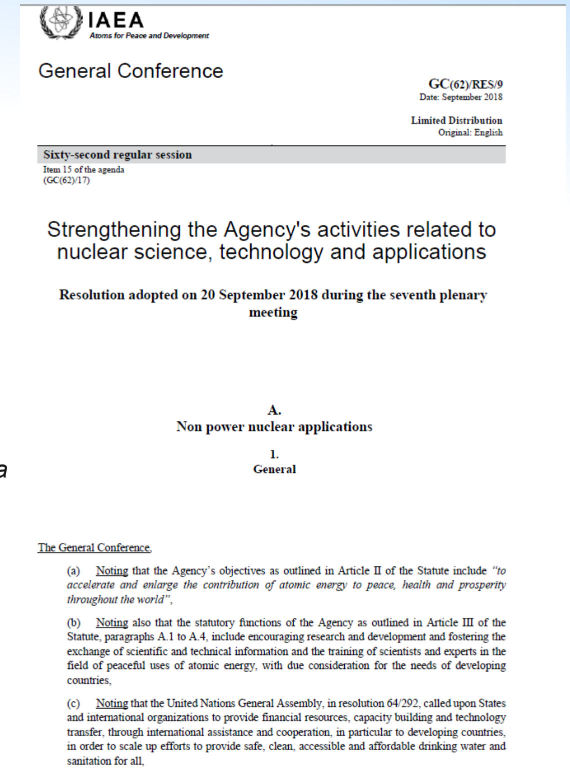
- **IAEA** actively supports its 170 MSs in improving their capabilities to develop and deploy **Advanced Reactors** and related innovative **Fuel Cycle** technologies with the aim to reduce the waste burden and to enhance nuclear power sustainability





- Through the:
  - Organization of Int. conferences and workshops
  - Publication of technical documents and reports
  - Coordination of international research activities (CRPs)
  - Management of specific databases

Biennial programmes taking into consideration MSs’ recommendations/requests expressed through:



IAEA
Atoms for Peace and Development

General Conference

GC(62)/RES/9
Date: September 2018

Limited Distribution
Original: English

Sixty-second regular session
Item 15 of the agenda
(GC(62)/17)

Strengthening the Agency's activities related to nuclear science, technology and applications

Resolution adopted on 20 September 2018 during the seventh plenary meeting

A.
Non power nuclear applications

1.
General

The General Conference,

(a) Noting that the Agency’s objectives as outlined in Article II of the Statute include *“to accelerate and enlarge the contribution of atomic energy to peace, health and prosperity throughout the world”*,

(b) Noting also that the statutory functions of the Agency as outlined in Article III of the Statute, paragraphs A.1 to A.4, include encouraging research and development and fostering the exchange of scientific and technical information and the training of scientists and experts in the field of peaceful uses of atomic energy, with due consideration for the needs of developing countries,

(c) Noting that the United Nations General Assembly, in resolution 64/292, called upon States and international organizations to provide financial resources, capacity building and technology transfer, through international assistance and cooperation, in particular to developing countries, in order to scale up efforts to provide safe, clean, accessible and affordable drinking water and sanitation for all,

- Yearly adopted resolutions: **GC(62)/RES/9**
  - *“Recommends that the Secretariat continue to explore, in consultation with interested Member States, activities in the areas of innovative nuclear technologies, such as alternative fuel cycles (e.g. thorium, recycled uranium and plutonium) and Generation IV nuclear energy systems including fast neutron systems, supercritical water-cooled, high-temperature gas cooled and molten salt nuclear reactors, with a view to strengthening infrastructure, safety and security, fostering science, technology, engineering and capacity building via the utilization of existing and planned experimental facilities and material test reactors, and with a view to strengthening the efforts aimed at creating an adequate and harmonized regulatory framework so as to facilitate the licensing, construction and operation of these innovative reactors”*
  - *“Calls upon the Secretariat and Member States in a position to do so to investigate new reactor and fuel cycle technologies with improved utilization of natural resources and enhanced proliferation resistance, including those needed for the recycling of spent fuel and its use in advanced reactors under appropriate controls and for the long-term disposition of remaining waste materials, taking into account, inter alia, economic, safety and security factors”*
- **Standing Advisory Groups (SAGs)**

  Standing Advisory Group on Nuclear Energy **(SAGNE):** a group of international experts advising (yearly) the **Director General** on nuclear power, fuel cycle and nuclear science issues
- **Technical Working Groups (TWGs)**

  Groups of international experts advising (yearly) the **DDG-NE** on the orientation and implementation of NE programmatic activities

Technical Working Groups relating to P&T

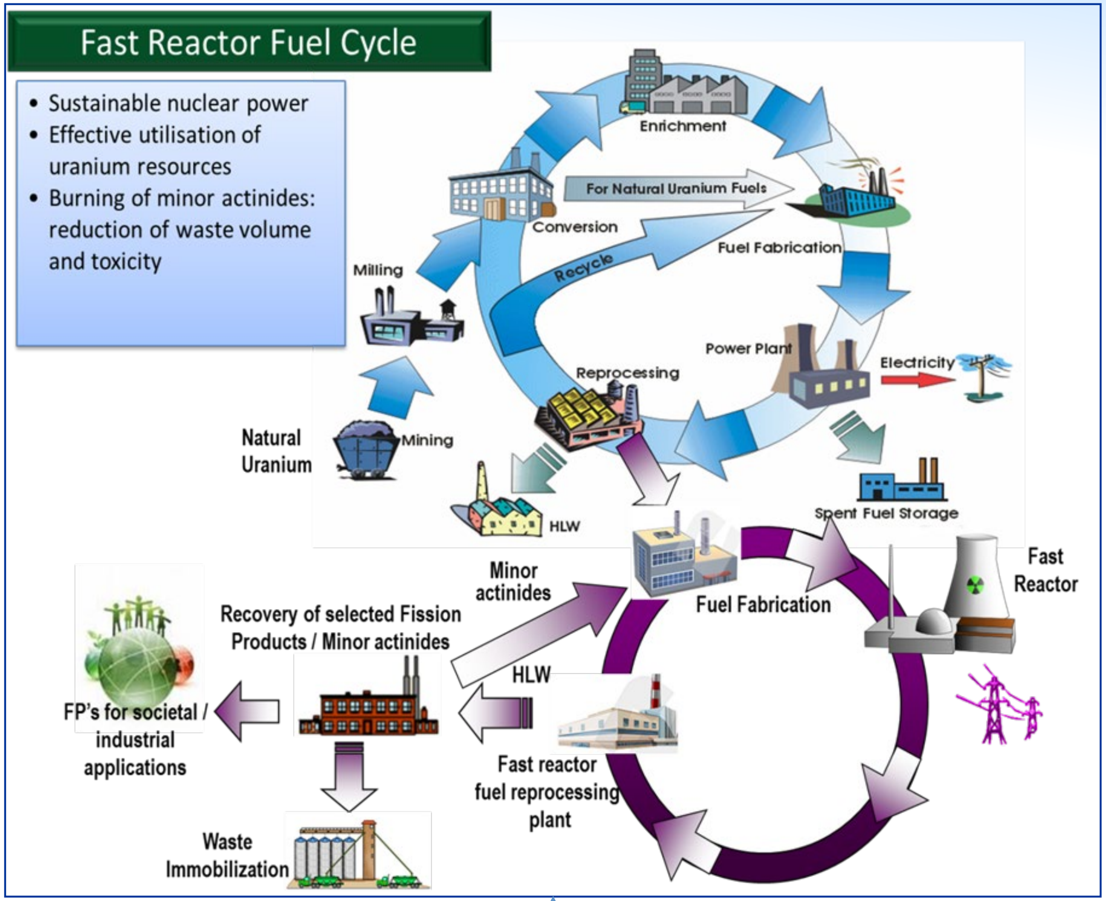
- **TWG FPT:** focuses on nuclear power reactor fuel performance and technology, nuclear core materials R&D, fuel design, manufacturing and utilization, coolant chemistry, fuel performance analysis and quality assurance issues
- **TWG-NFCO:** focuses on nuclear fuel cycle options with an emphasis on spent fuel management (storage, reprocessing and recycling), innovative fuel cycles and nuclear materials management
- **TWG-FR:** assists the IAEA in formulating an international vision applicable to fast spectrum transmutation systems, both critical and subcritical, for energy production and transmutation of long-lived radionuclides

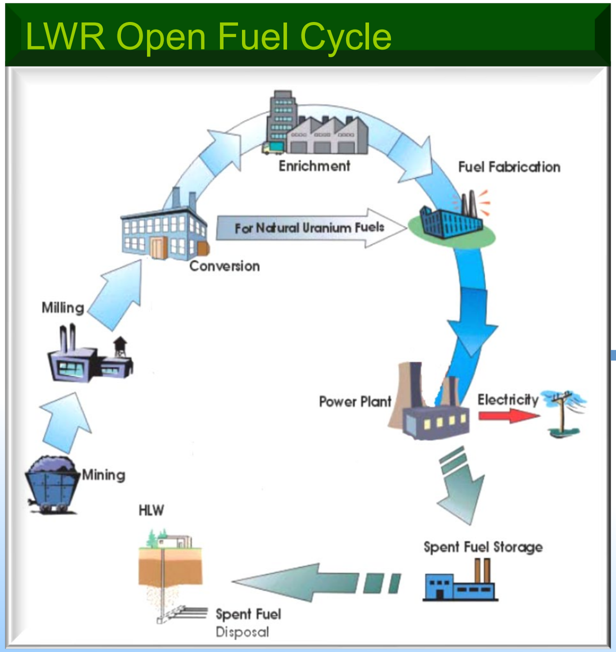
Vienna, April 2018

Buenos Aires, May 2016

Strategies and Opportunities for 2050

- Economically viable fuel cycles
  - Recycling of valuable materials
- Safe
- Environment-friendly
  - Waste burden minimization
- Proliferation resistant
- Flexible to adapt to any policy evolution





IAEA's activities on Fast Reactors

Safety Design Criteria

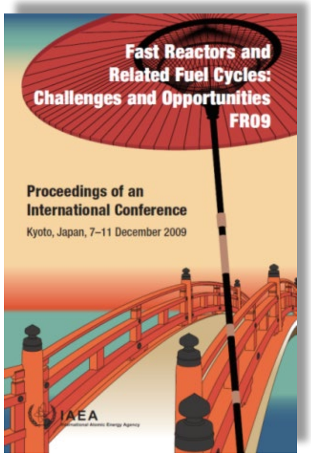
Fast Reactor Knowledge Preservation (FRKP portal)

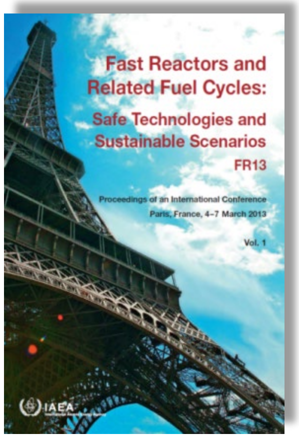
SFR Simulator

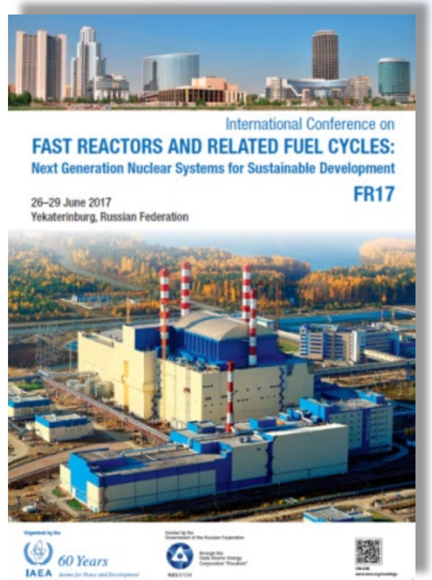
Validation and Verification through Benchmarking

Handbook on Sodium Properties

3rd International Conference on Fast Reactors and Related Fuel Cycles (FR17)







Yekaterinburg
Russian Federation
26-29 June 2017

Scientific Secretaries:

- Vladimir Kriventsev (IAEA, NE-NPTDS)
- Amparo Gonzalez-Espartero (IAEA, NE-NFCMS)

Main statistics and conclusions of the Conference FR17

Statistics

- 449 Scientific papers presented
  - 243 Orals and 206 Posters
- 558 Participants from 27 MSs
- 18 participants from 6 International Organisations including the IAEA
- 36 Grants awarded
- Technical tour BN-800 and BN-600
- YGE panel with 6 orals presentations

Main Conclusions

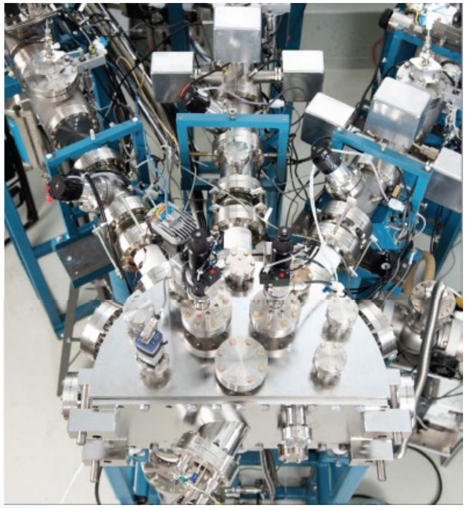
- Fast reactor technology remains a proven option as a sustainable source of energy for many generations to come
- Sodium cooled fast reactor technology remains the most mature technology; Efforts are now focused on enhancing safety and improving economic efficiency
- International cooperation on fast reactors and related fuel cycles technology is crucial
- Fast reactor community recognise the benefit of this type of conferences and encourage the International Atomic Energy Agency to continue supporting them

IAEA's activities on Advanced Fuels

CRPs on "Accelerator Simulation and Modelling of Radiation Effects": SMoRE-1 (2008-2012) and SMoRE-2 (2016-2020)

- Background
  - Fast Reactor designs have harder neutron spectra than "traditional" PWRs, BWRs, PHWRs, *etc.*
  - Need to develop materials (for fuel cladding, wrappers, etc.) capable of withstanding 100-150 dpa
  - New FR structural materials need to be tested
  - ☹ Very few fast reactors are available to test and screen candidate materials

- Short-time irradiation tests with ion beams
  - Very high dose rates possible with good control
  - Good control over T, *etc.*
  - Capable of generating the same responses: dislocation loop densities, RIS, swelling



IAEA's activities on Advanced Fuel Cycles

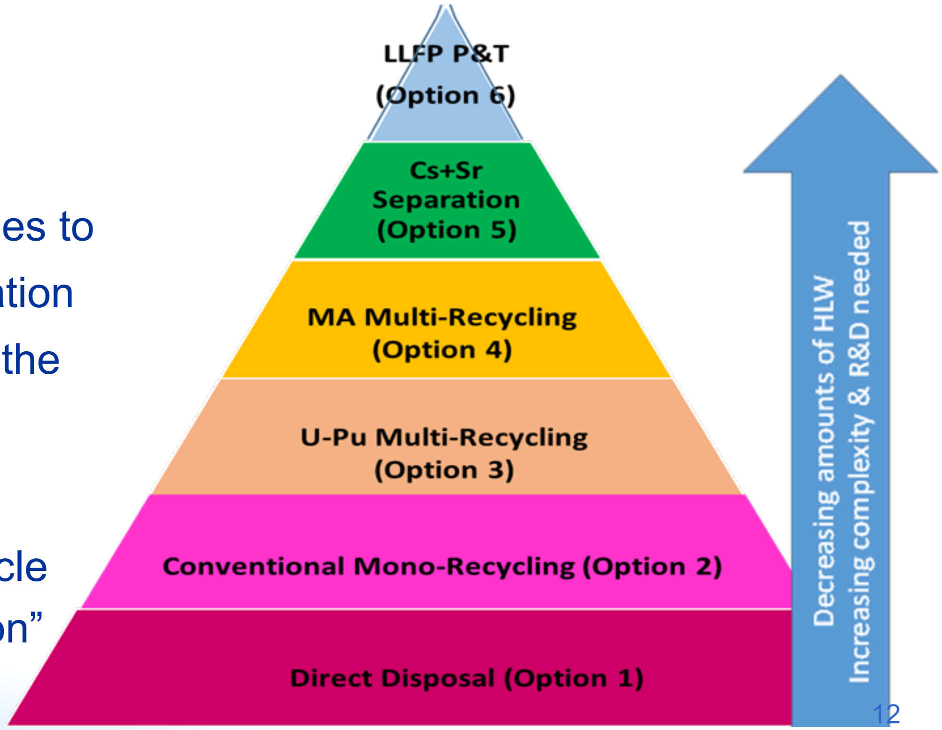
Two **Technical Meetings** were organized in Vienna on "Advanced Fuel Cycles for Waste Burden Minimization" (21-24 June 2016 and 17-19 October 2017)

Main Objective: To review and update the developments in advanced fuel cycles leading to minimization of waste burden

Main output:

To draft a concise and brief report* aimed at reviewing and updating the technological developments in current and advanced fuel cycles to provide policy and decision makers with information about how different FC strategies can minimize the burden of generated waste

***Title:** "Existing and Advanced Nuclear Fuel Cycle Technical Options for Waste Burden Minimization"



CRP on "Accelerator Driven Sub-critical Systems (ADS) and Use of Low Enriched Uranium (LEU) in ADS" (2015-2019)

Main Objectives

- Focus on developing LEU ADS Systems
- Continue development of analytical techniques
  - Experimentation in facilities
  - Benchmarks against analytical results
  - Development of new measurement techniques
  - Sensitivity studies between various cross section libraries
- Application development and demonstration
  - **Nuclear Waste Transmutation**
  - Radioisotope production
  - Material irradiation
  - Thorium fuel cycle development

22 participants from 17 MSs

IAEA-TECDOC-1821 "*Use of Low Enriched Uranium Fuel in Accelerator Driven Sub-critical System (ADS)*" published in August 2017

Argonne NATIONAL LABORATORY

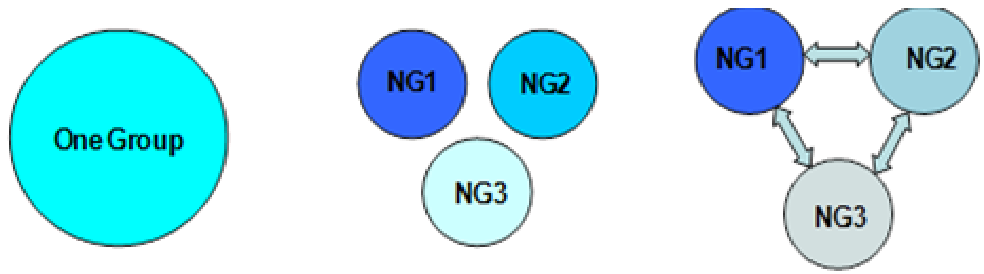
Analytical Concepts for disposing US SNF

- ADS systems using liquid mobile fuel
- Liquid metal systems provide favourable fast neutron spectrum for transmutation
- MAs particles are suspended in the liquid metal
- Reactivity Measurements are performed at the Kharkov Institute of Physics and Technology (Ukraine)

International Project on Innovative Nuclear Reactors and Fuel Cycles (INPRO) Task “Global Scenarios”:

Heterogeneous world model introduced in GAINS

CP on SYNERGIES and ROADMAPS



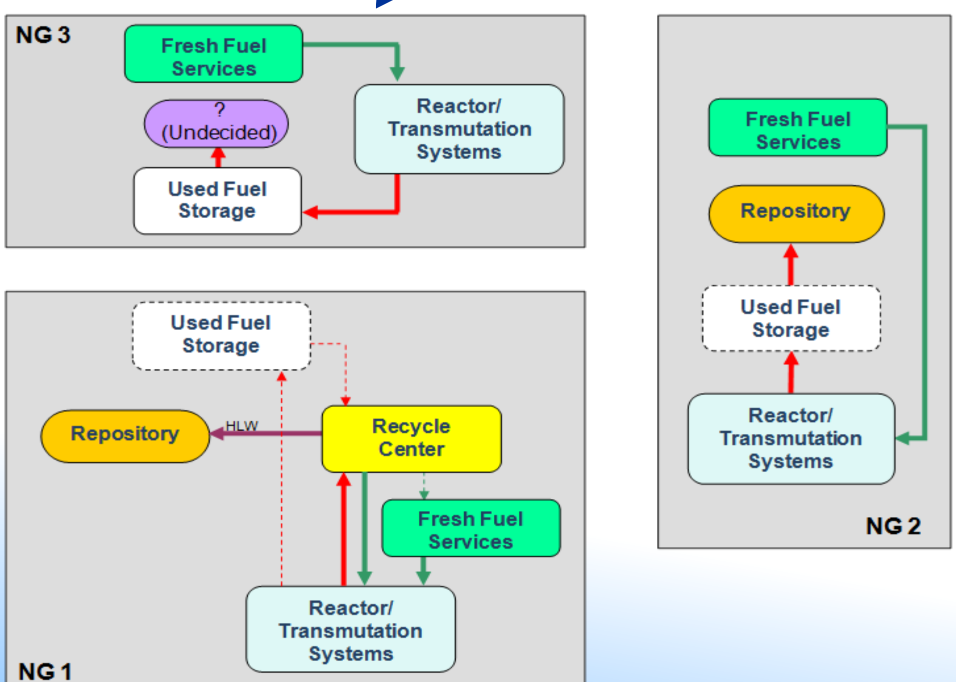
(a) Homogeneous   (b1) Heterogeneous Non-Synergistic   (b2) Heterogeneous Synergistic

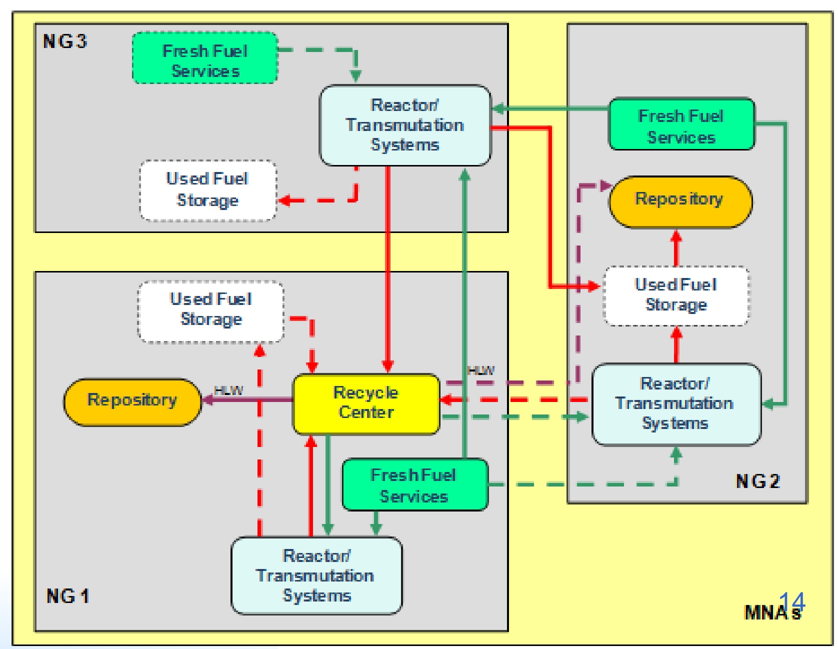
Non-personified, non-geographical groups of countries with different policies regarding the fuel cycle back end:

NG1-recycling strategy;

NG2-direct disposal/reprocessing abroad strategy

NG3- looking for minimal NFC infrastructure: disposal or reprocessing abroad





IAEA Databases

Advanced Reactor Information System (ARIS)

https://aris.iaea.org

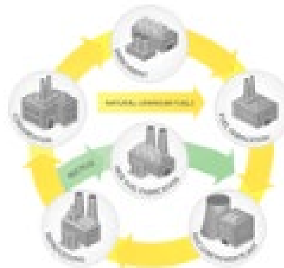
Catalogue of Facilities in Support of LMFNS (LMFNS catalogue)

https://https://nucleus.iaea.org/sites/lmfns/Pages/Home.aspx

Integrated Nuclear Fuel Cycle Information System

http://infcis.iaea.org

IAEA | INFCIS



Nuclear Fuel Cycle Information System (NFCIS)

NFCIS covers civilian nuclear fuel cycle facilities around the world. It contains information on operational and non-operational, planned, and cancelled facilities.

All stages of nuclear fuel cycle activities are covered, starting from uranium ore production to spent fuel storage facilities.

Post Irradiation Examination Facilities Database (PIE)

PIE is derived from a catalogue of such facilities worldwide that the IAEA issued in the 1990s. It includes a complete survey of the main characteristics of hot cells and their PIE capabilities.

Minor Actinide Property Database (MADB)

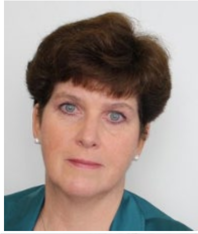
MADB is a bibliographic database on physico-chemical properties of selected Minor Actinide compounds and alloys. The materials and properties are selected based on their importance in the advanced nuclear fuel cycle options.

Contributions from NE colleagues

- Stefano Monti S.Monti@iaea.org
  Nuclear Power Technology Development (Section Head)

- Jon Philips J.R.Phillips@iaea.org
  INPRO (Section Head)

- Frances Marshall F.Marshall@iaea.org
  Research Reactor Section (Nuclear Engineer)



- Amparo Gonzalez Espartero a.g.espartero@iaea.org
  Nuclear Fuel Cycle and Materials Section (Technical Leader)

Thank you!

More information:
https://www.iaea.org/events/management-of-spent-fuel-conference-2019

New CRP Proposal on Fuel Materials for Fast Reactors (2019-2022)

CRP Overall Objective

To promote among interested Member States the coordination of fast neutron irradiation experiments and post-irradiation examinations of materials for fast reactors, to standardize and qualify relevant techniques and modelling methods and to ensure sharing and dissemination of knowledge and expertise

Expected Research Outputs

- A common database on prototypic commercial irradiations as well as experiments performed in research reactors
- Results of computer modelling of a selected number of cases with the use of different fuel performance codes

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Innovative Fuel Cycles

Fuel Cycle Option	Description	Degree of processing / separations	Fuel cycle impact
1	Open fuel cycle	Waste conditioning only – no separations	All SNF to GDF; no resource conservation (U, GDF space)
2	(Pu) Mono-recycling	Single recycle of thermal (U,Pu) MOX fuels	Small savings in U utilization and GDF space; spent MOX fuel generated
3	(Pu) Multi-recycling	Multi-recycling of U and Pu in FRs and LWRs fuels	Optimize resource utilization (use of DU); stabilization of Pu inventory; requires transition to FRs
4	Minor actinide recycling	Recycling of minor actinides	Reduction long term heat loading, reduced GDF space; requires accelerator driven systems (ADS) or FRs
5	Fission product (FP) separation	Separation of heat generating FPs, LLFP (I, Tc, Ru) for recycle or decay storage	Optimized GDF space; decay storage facilities needed
6	Partitioning and Transmutation	Separation of residual radionuclides for burning in (ADS)	Theoretical maximum benefits in WBM; requires advanced technologies including ADS

IAEA Publication on "Existing and Advanced Nuclear Fuel Cycle Technical Options for Waste Burden Minimization" under preparation

Example of ToC for U/Pu Mono-recycling Option

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