Discussion on Nuclear Energy Series on Waste Burden Minimisation and Coordinated Research Project on Advanced Fuel Cycles

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Technical Meeting on Strategies and Opportunities for the Management of Spent Fuel from Power Reactors in the Longer Timeframe, Bahadurgarh (India), 25-29 Nov 2019
Options for Managing Spent Fuel

Factors Influencing the Choice of Spent Nuclear Fuel Management Strategy

- Utilization of natural resources
- Experience of different nuclear fuel cycles
- National energy strategy
- Radioactive waste management
- Safety and Security
- Nuclear fuel cycle economy
- Future development of FRs and related nuclear fuel cycles
- Non-proliferation
- Public acceptance
- Political and international acceptance
Nuclear fuel cycle options

• Nuclear Power sustainability:
  – Nuclear fuel must be adequately designed and manufactured to enable a reliable and safe operation of nuclear power plants
  \[\Rightarrow\] Continuous improvements in technology and engineering are therefore required

• Nuclear fuel cycle economy and competitiveness:
  – Optimizing the use of natural resources (U) by recycling valuable materials (e.g., U, Pu)

  \[\Rightarrow\] This results in different fuel cycle options, some already implemented and others may be deployed in the future
Strategies and Opportunities for the Management of Spent Fuel in the Longer Timeframe

- **Advanced reactors** implementation
- Environment-friendly **innovative fuel cycles**:  
  - Fully closed (recycling valuable materials)
  - Natural resources preservation
  - **Waste burden minimization**
  - Proliferation resistant
  - Flexible to adapt to any policy evolution

Towards Fully Closed Cycle?
Towards Waste Burden Minimization

• Radiotoxicity

- Minimizes the waste lifetime and radiotoxicity
- Reduces thermal output of generated wastes increasing repository “lifespan”

• Thermal Output

Recycling Pu and MA:
Today and tomorrow’s challenges

• **Today**
  – Improve nuclear fuel performance and behaviour
    • Fresh (in reactors) and spent (in storage or recycling)
  – Bridge the gap until final disposal becomes operational
    • Keep the nuclear fuel cycle option flexible to adapt to any policy evolution

• **Tomorrow**
  – Make Nuclear Power sustainable
    • Preserving natural resources
    • Minimizing nuclear waste burden for future generations
      – Fully closed (recycling valuable materials)
Previous IAEA’s Activities on this matter

- Technical Meeting on “Advanced Fuel Cycles to Improve the Sustainability of Nuclear Power through the Minimization of High Level Waste”, 17-19 October 2017, Vienna

Main Objective: To review and update the developments in advanced fuel cycles leading to minimization of waste burden and to identify potential topics of common interest to launch a Coordinated Research Project (CRP)

Participants from 11 MSs:
China, France, Hungary, India, Japan, Republic of Korea, Poland, Russia Federation, UK, Ukraine, USA

Discussions on:
- National approaches and present status of FR fuel cycles
- State of the art of advanced separation technologies
- Feasibility of transmutation of TRU nuclides, MAs and LLFPs
- Recovery of platinum group metals and useful FPs
- Strategies and technologies aimed at WBM
IAEA’s Activities on Strategies and Opportunities for the Management of Spent Fuel in the Longer Timeframe

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

Comparison against different criteria
Criteria for Comparison of Fuel Cycle Options for Waste Burden Minimisation

1. Environmental impact
   1. Waste burden minimization
   2. Natural Resources Preservation
2. Nuclear Facilities and Infrastructures
3. Industry development
4. Services abroad
5. Challenges associated to the Size of Country’s Nuclear Programme
6. Human resources
7. Country’s nuclear legislation to reuse nuclear materials
8. Proliferation risks
9. Security risks
10. Public support
11. Technology readiness and potential access to this technology
New IAEA Coordinated Research Project (CRP) on Innovative Fuel Cycles

Main Objective is to serve as a platform of sharing and discussing:

- Fuel cycle options for advanced reactors (Gen IV, SMRs, etc)
- Impact of new developments in fuel fabrication (accident tolerant fuels, new cladding materials, etc) in the backend of the fuel cycle
- To identify factors that influence technology choice to be deployed (cooling time, burn-up, etc.) for advanced fuel cycle options (aqueous and pyro processes)
- Comparison of different innovative cycle options against different criteria (wastes produced, non-proliferation aspects, TRL, scale up, etc)
- Different approaches for recycling valuable FPs

- GENIORS Project’s objectives
  - In the longer term, the project’s results will facilitate radioactive waste management by reducing its volume and radiotoxicity, and support a more efficient utilisation of natural resources
  - Developing scientific knowledge and expertise on nuclear fuel recycling, and taking account of waste reduction, environmental parameters and hypothetical accidental operations
Thank you!
IAEA’s Activities on Strategies and Opportunities for the Management of Spent Fuel in the Longer Timeframe

• LWRs
  • REMIX process (Russian Fed.)
  • Corail and MIX processes (France)
• LWRs/FRs
• FRs