(Panel 2)
Sustainability of Advanced Fuel Cycles

Path towards converging visions of sustainability linking to advanced nuclear fuel cycle

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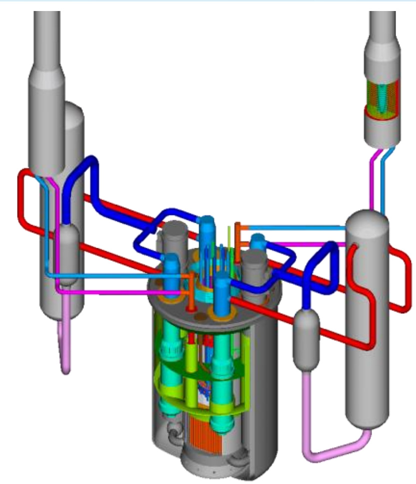


Challenging of Nuclear Fuel Cycle

- **A number of challenges to be faced**
  - Competitive nuclear energy under the high carbon pricing and financing control
  - **A number of challenges to be faced : Requirements**
    - Continuous enhancement of safety and security culture
    - Radioactive waste management
    - Nuclear material control
  - **Substantial contribution to meet world's energy demand**
    - Gen-IV Reactor development and related nuclear fuel cycle technologies
    - Pursued to enhance longer-term sustainability

- **Identification of nuclear fuel cycle options**
  - **Nation's strategies** to provide nuclear energy with its various objectives
  - **Fuel cycle options** that can be best suitable for the country

Evaluation of Nuclear Fuel Cycle Options

- **Different fuel cycle options by each country**
  - **Evaluation of advanced fuel cycle options**
    - Sustainability
    - Environmental-friendliness
    - Proliferation-resistance
    - Economics
    - Technologies maturity level

- **Common consequence of nuclear fuel cycle options**
  - Key evaluation driver of sustainability : **Uranium resource**
  - Environmental-friendliness : **Spent fuel and HLW amount to be disposed**
  - Proliferation-resistance : **Pu to be disposed**

Fuel Cycle Schemes

- **Once-through Fuel Cycles**
  - Direct disposal
  - Selection of HLW disposal site will be a critical factor
    - Relatively low cost and deep geological repositories have been widely accepted in several countries
    - No repositories are yet in operation
    - Preferred selection of Low and Intermediate level Waste (LILW) disposal facility

- **Closed Fuel Cycles**
  - SF treatment and reuse at SFR reactor
    - Aqueous process : Partially
    - Pyroprocess : Closed
  - Proliferation concern has to be resolved

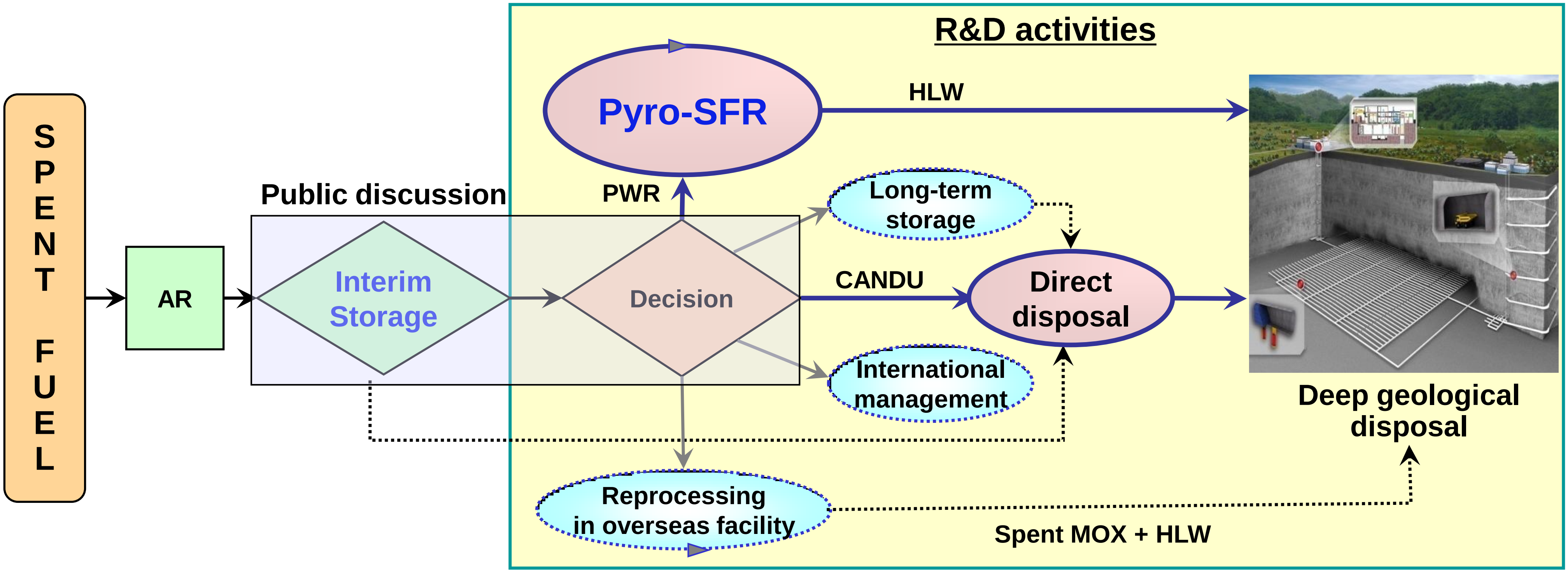
Comprehensive Standard Methodology

- **Driven by country-specific circumstance**
  - Nuclear fuel cycle option can't be superior in all aspects of sustainability, waste management, PR and so on
  - Comparison of the options : extremely complicated.
  - Recognizing selection of nuclear fuel cycle option : Mainly driven by county-specific circumstances that ultimately determine national strategies
  - No comparative assessment of such national options has been undertaken.

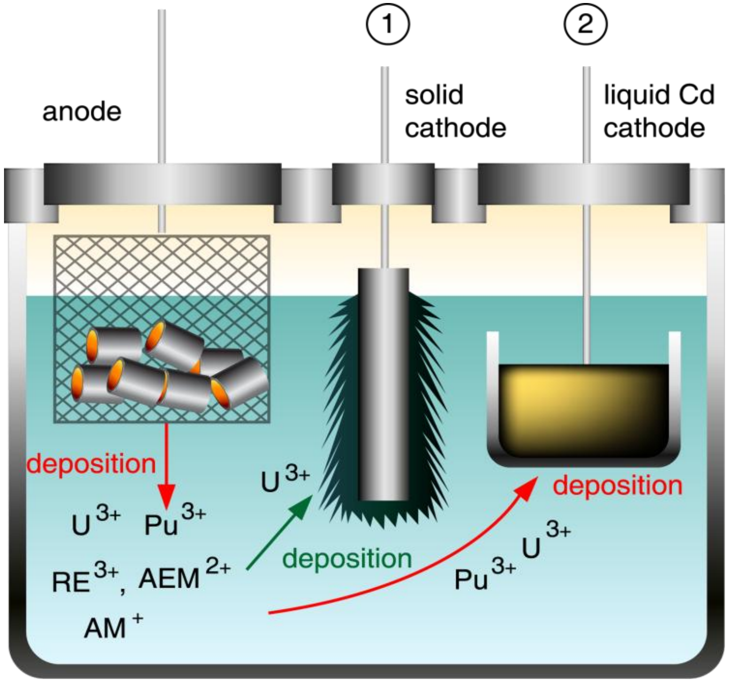
- **Comprehensive standard methodology for objective evaluation of various fuel cycle options**
  - Provide potential information to policy-decision maker

Open Discussions and SF R&D Activities

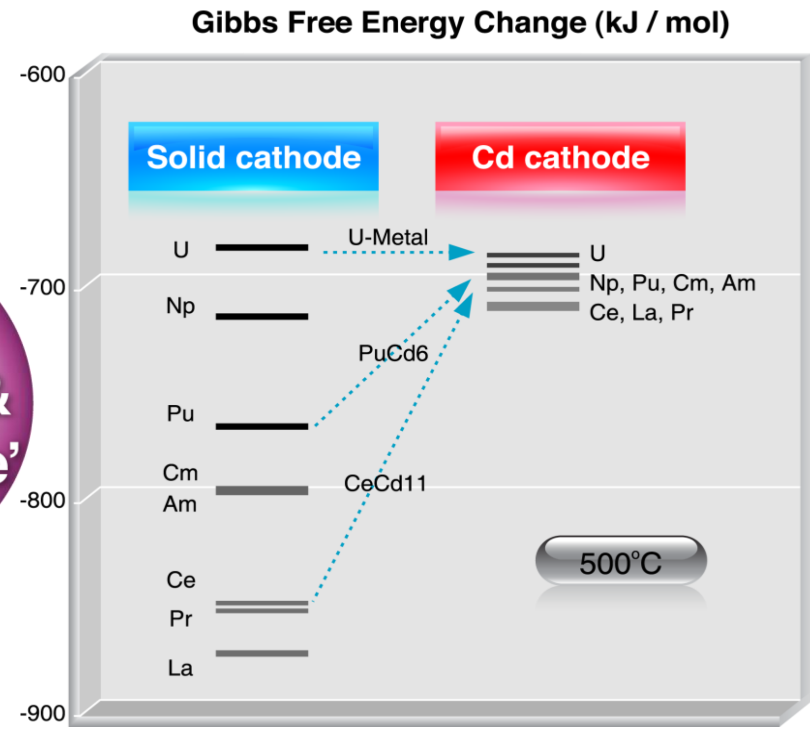
- On-site SF storage limit will be reached from 2016
- Spent fuel management policy will be established based on open discussions and public consensus
  - R&D activities to provide technical information for decision making process



PR-Oriented Pyroporcessing



Pyro for 'Dirty Fuel & Clean Waste'



LLNL (1994)

- The chemically impure plutonium produced by the pyrometallurgical process could be used to make a bomb without further separation?
- The transuranic impurities render the material far too hot (thermally and radioactively), and far too many spontaneous neutrons, to make it at all feasible.
- [W.H. Hannum, G.E. Marsh and G.S. Stanford, 'Purex and pyro are not the same']

Overall Impact Factors on Sustainability (1)

- **Resource utilization**
  - Increased plant capacity for the next decade continues to add uranium resource and separation work unit demand.
  - Prospective increase in the use of reprocessed uranium would have beneficial impact on resource utilization and resource availability

- **Waste management**
  - Reprocessing and recycling technology
    - Lead to reduction of spent fuel inventories and
    - Removal of most of fissile material in the ultimate waste for disposal alleviates the long-term waste burden.
    - Implementation of deep geological disposal remains a key challenge for the industry and for governments

Overall Impact Factors on Sustainability (2)

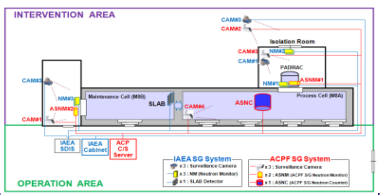
- **Proliferation resistance and Physical protection**
  - Consumption of recycled uranium and TRU reduces potential attractiveness for non-peaceful use.
  - Any wider spread of reprocessing or enrichment carries with it proliferation challenges, which continue to be the subject of national and international efforts to enhance the safeguards and non-proliferation regimes
- **Safety**
  - Reprocessing and recycling technology
    - some relaxation in criticality constraints and safeguards requirements enables by the removal of the majority of the fissile material in the final waste form going to a repository
- **Economics**
  - Major challenge is facing for the reduction of construction time and capital costs for the advanced nuclear fuel cycle

Poliferation Resistance R&D (1)

- **Objectives**
  - Development of PR/PP enhancement technologies for pyroprocess
  - Development of safeguards technologies
  - Development of hot cell design concept

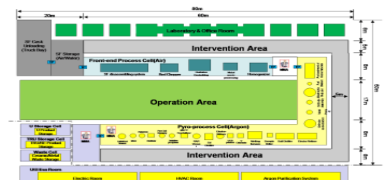
2002 | 2007 | 2012 | 2017 | 2022

Milestone → **ACPF** Safeguards Implement. → **PRIDE** SG System Dev. → **REPF** 3S by Design → **KAPF** 3S by Design →



ACPF (Lab. Scale, SF)

PRIDE (Eng. Scale, Simfuel)

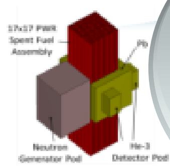


REPF (Eng.-scale, SF)

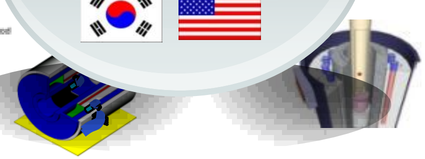
KAPF (Prototype)

- **International Collaboration**

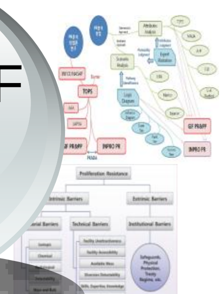

IAEA
(ROK-IAEA MSSP)



US
(Joint Fuel Cycle Study)

INPRO/GIF
(PR/PP)



Poliferation Resistance R&D (2)

- **Risk of proliferation in any facility that handles nuclear materials**
  - A certain level of risk of proliferation in any facility that handles nuclear materials
  - Most intrinsic barriers are ineffective against diversions initiated by states
  - More important question is how to enhance the proliferation resistance of the given process
- **Enhancements of proliferation resistance**
  - Achieved through application of measures suitably combined to strengthen the material, technological, and institutional barriers to proliferation.
  - Development of a "risk reduction methodology" and
  - Implementation of a "safeguards-by-design" (SBD) approach
- **A Nuclear material accountancy system**
  - NDA, DA, C/S

Summary

- **Evaluation of nuclear fuel cycle options**
  - Selection of nuclear fuel cycle option is mainly driven by county-specific circumstances that ultimately determine national strategies
  - Comprehensive standard methodology for objective evaluation of various fuel cycle options would provide potential information
- **Pyroprocessing**
  - KAERI has developed an environment-friendly and proliferation resistant pyroprocessing for spent fuel treatment
  - To recover useful materials such as U, TRU, and reduce the volume and radiotoxicity of spent fuel
- **Infrastructure**
  - Proving transparency and escalating technology improvement in terms of technical, economical and proliferation-resistance aspects