Application of a graded approach to the concept of fuel recycling

IAEA technical meeting on "Back end of the fuel cycle considerations for small modular reactors"

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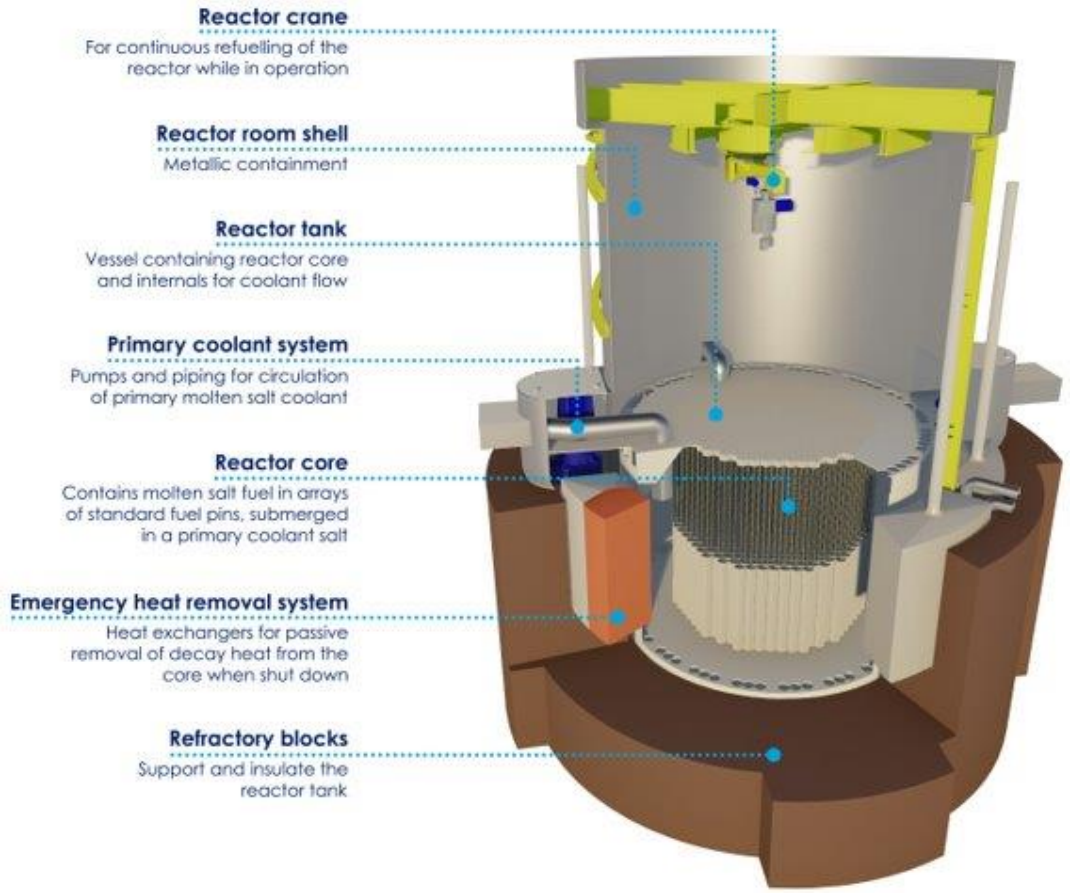
Introduction

Stable Salt Reactor – Wasteburner (SSR-W)

- High temperature, fast neutron, molten salt reactor
- 300-500 MWe per reactor
- Uses recycled nuclear waste as fuel

WAste To Stable Salt (WATSS)

- High temperature, molten salt-based separation process



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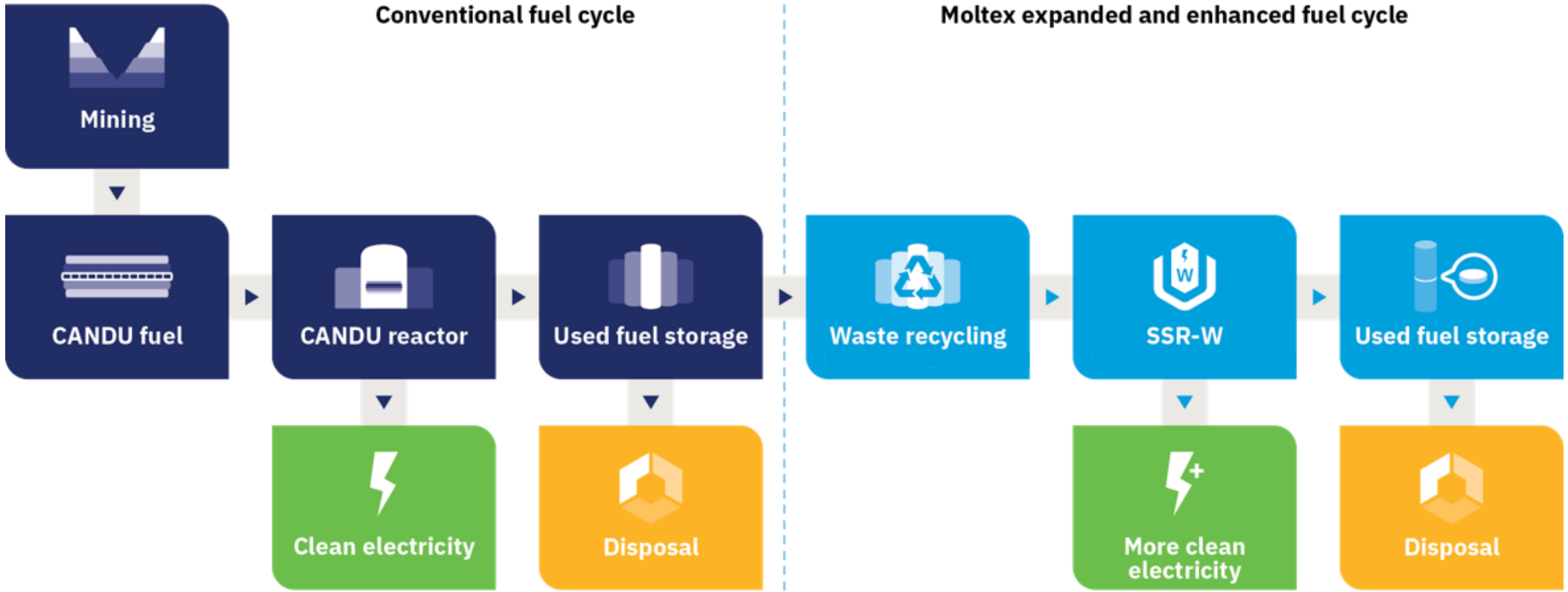
WATSS / SSR-W synergies with legacy waste management



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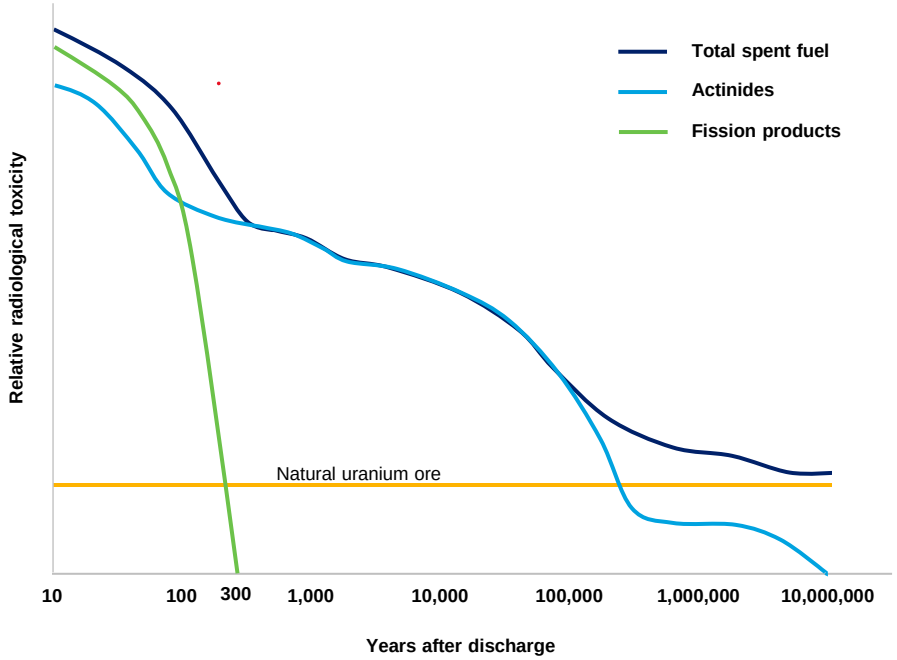
WATSS – SSR-W synergies with legacy wastes management



Introduction

Closing the fuel cycle important in quest for sustainable energy production

Recycling / reprocessing seen as sensitive activities due to proliferation concerns

How to reconcile these differences?

Historical background

Evolution of US policy involving reprocessing / recycling of spent fuel

- Eisenhower (50s): Reprocessing viewed as natural and desirable part of fuel cycle
- Kennedy (60s): Breeder reactors and “plutonium economy” vital over the long term
- Carter (70s): Indefinite ban on reprocessing and recycling
- Reagan (80s): Lifting of the ban, but no financial support
- Bush (2000s): Emphasis on the desirability of avoiding “separated plutonium”

Efforts to update the reprocessing regulatory framework in the 2000’s and 2010's – Did not come to fruition, but identified key gaps

Definitions

Widely adopted wording for potential definitions of reprocessing / recycling

- Reprocessing: Separation of plutonium and uranium from intensely radioactive fission products **and other transuranic elements.**

- Recycling: Separation of the constituents of spent nuclear fuel and refabrication of fresh fuel containing plutonium, **minor actinides and possibly some fission products.**

Fundamental difference: level of Pu separation from other species

Proliferation aspects – recycled product

Proliferation-resistant aspects of non-separated Pu / technical barriers to proliferation

- Radioactivity
- Spontaneous neutrons emission
- Heat generation
- Metallurgical behaviour of plutonium metal

Proliferation aspects – recycled product

Relative contribution of chemical species to the identified barriers to proliferation

	Radioactivity	Neutrons production	Heat generation	Alloying behaviour
Minor actinides	+ (1)	++	+ (1)	-
Lanthanides	++ (2)	-	+ (2)	++
Other fission products	++	-	+	+

++: Important barrier to proliferation / **+**: significant contribution to proliferation resistance / **-**: negligeable impact
(1) Several decades after discharge / (2) Within first year after discharge

Relevance of the concept of “non-separated plutonium”.
Framework for the application of a graded approach.

Proliferation aspects – recycling technologies

Limitations of the potential misuse of different recycling technologies

Could a recycling plant be converted to produce separated plutonium?

For each recycling/reprocessing technology:

- Is the technology readily usable to produce separated plutonium?
- Are there proven processes to bridge the gap?
- Could these processes be developed based on the fielded recycling plant?
- Can the required equipment be fitted in the existing plant?

Proliferation aspects – recycling technologies

Factors driving the potential for conversion of a recycling facility to produce separated Pu, depending on the separation technology

	PUREX	Other water-based separation processes	Pyroprocessing using electrochemical processes	Pyroprocessing based on chemical redox potential
Facility readily useable for purified Pu production	X	-	-	-
Technologies to bridge the gap are proven	X	X	-	-
Required technologies could be developed based on recycling facility processes	X	X	(X)	-
Required equipment can be fitted in existing recycling facility	X	X	X	-

Graded proliferation resistance.

Concluding remarks

- Legitimate interest in recycling nuclear waste in a quest for sustainability / fuel availability
- Leverage needed to promote proliferation-resistant recycling technologies
  - Specific definitions for the concepts of **reprocessing** and **recycling** (separated / non-separated product)
  - Acknowledgement of a **graded proliferation resistance**
    - Water / organic solvent-based liquid-liquid extraction
    - Pyroprocessing using electrochemical processes
    - Molten salt-based pyroprocessing relying exclusively on chemical redox potential

Thank you

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