Global Overview of Waste Management Strategies Available for a Nuclear Power Programme

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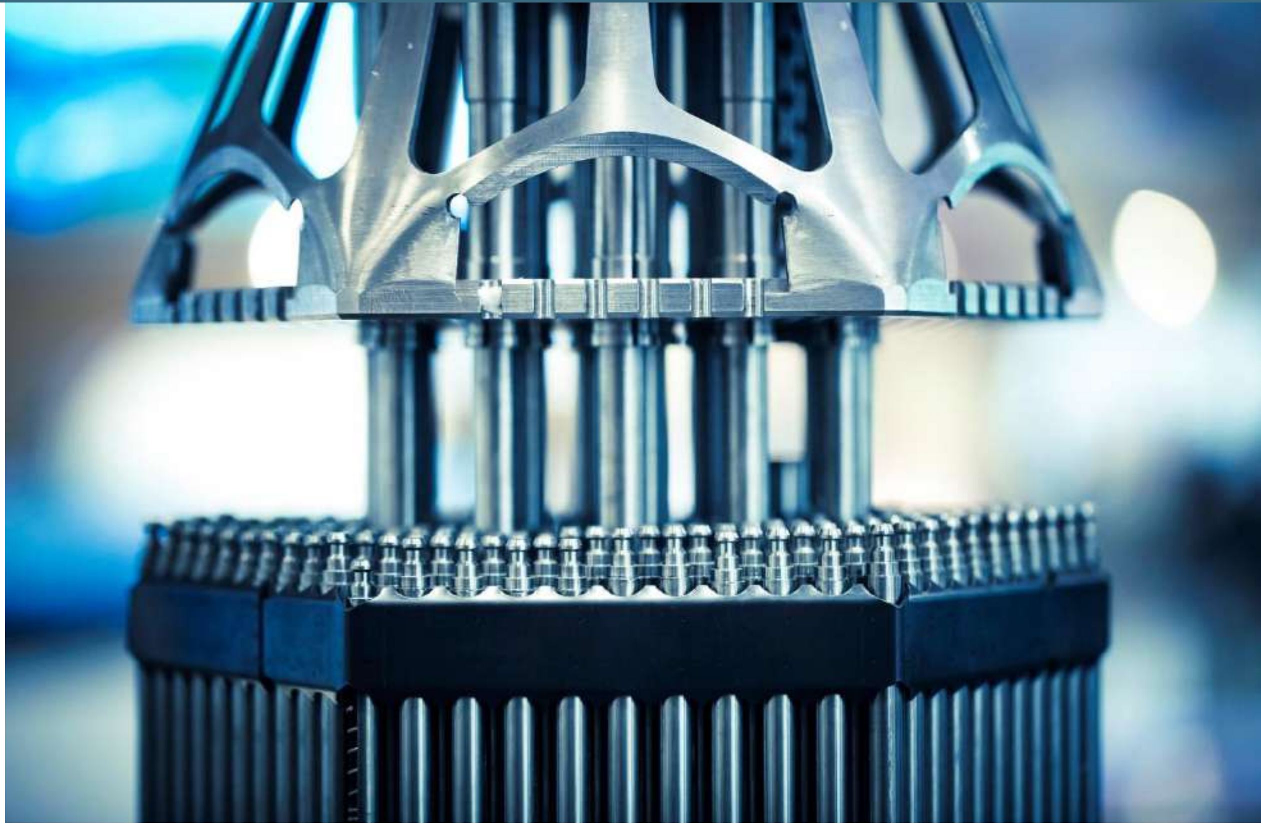
Spent Nuclear Fuel – what to do with it?

- Store it temporarily and figure out what to do with it later.
  - On-site “wet” storage in spent fuel pools
  - On-site storage in Independent Spent Fuel Storage Installation (ISFSI)
  - Off-site storage in common waste facilities
- Bury it
  - Permanent geological disposal
  - Monitored retrievable storage
- Reprocess it into mixed oxide (MOX) fuel
- Burn it in a “waste burner” rector



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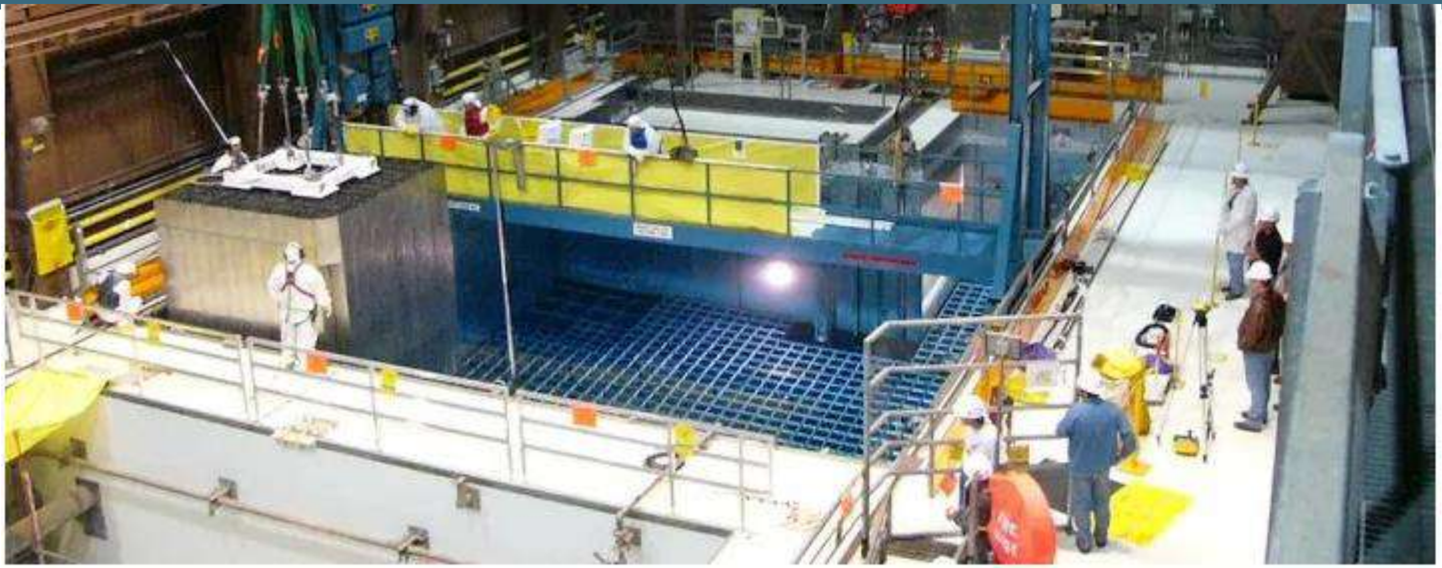
Spent Fuel

- High-level wastes are hazardous because they produce fatal radiation doses during short periods of direct exposure.
- 10 years after removal from a reactor, the surface dose rate for a typical spent fuel assembly exceeds 10,000 rem/hour – far greater than the fatal whole-body dose for humans of about 500 rem received all at once.
- Transuranic wastes, sometimes called TRU, account for most of the radioactive hazard remaining in high-level waste after 1,000 years.

Temporary Storage



- On-site storage can be either “wet” or “dry”
- “Wet” storage is in the spent fuel pool
- “Dry” storage is in casks either on-site or off-site

Temporary Storage – Spent Fuel Pool

- Depending on the design of the reactor plant, can be large enough to store decades worth of used fuel.
- Can be used as part of a wait-and-see strategy, and final decision can be postponed for years.
- Requires continuous cooling.
- Pools can develop leaks, and the neutron absorbers can degrade over time.
- Represent a security risk.

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Temporary Storage – Dry Cask Storage

- Requires a cooling-off period in the Spent Fuel Pool before fuel is inserted into casks
- Multi Purpose Cask (MPC) designs allow for storage and transportation
- Casks are extremely robust and do not require cooling other than convection.
- Delays decisions on final disposition for 100+ years

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Temporary Storage – Dry Cask Storage

- Consists of a cylindrical shell, baseplate, lid, port covers and closure ring which form the confinement boundary for the stored fuel assemblies.
- The confinement boundary is a seal-welded enclosure of all stainless steel construction.
- Helium-filled.
- The fuel baskets are composite cell structures made of stainless steel.
- Ventilated overpacks.

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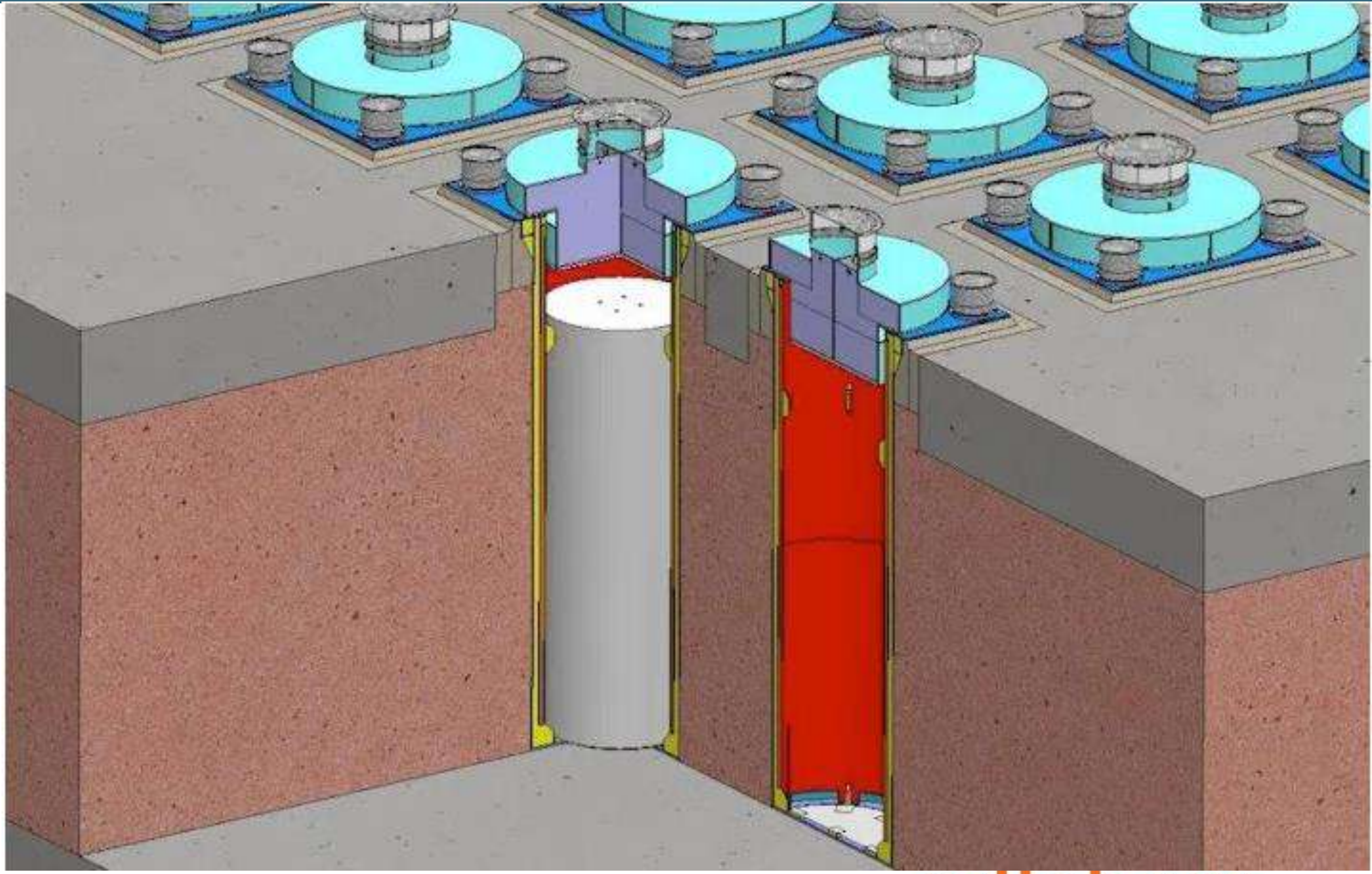
Consolidated Interim Storage Facilities

- Canisters can be stored at a remote common storage site.
- In the USA, the NRC is currently reviewing two applications for Consolidated Interim Storage Facilities in Texas and New Mexico
- Holtec's HI-STORM system is shown here, AREVA also has a design.



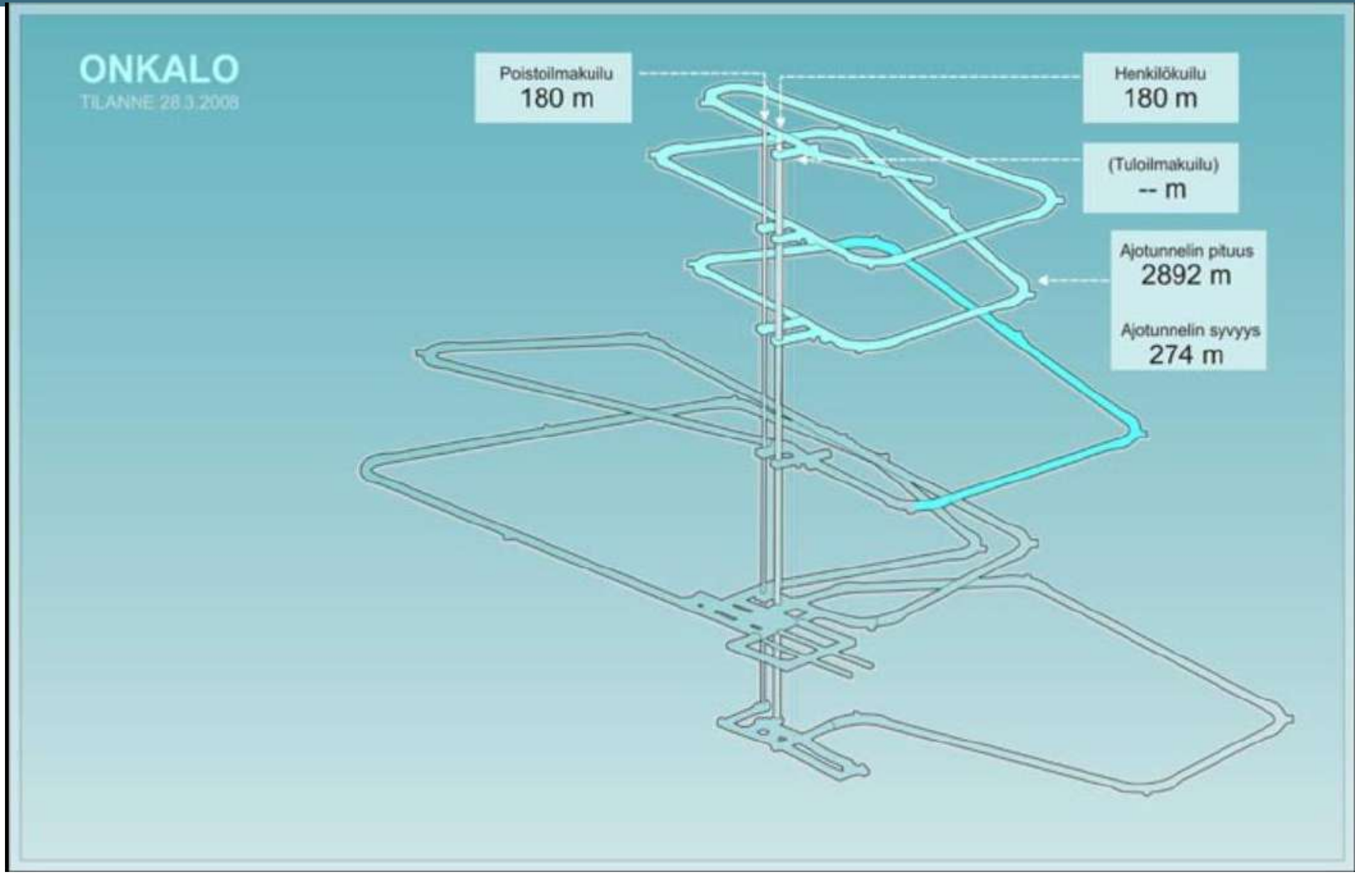
Permanent Geological Disposal

- Site selection is key.
- Geology must be extremely stable over millennia
- Oldest man-made structure, the Megalithic Temples on Malta, dates only to 3600 BC. Other
- Canada, Finland, France, Switzerland, Sweden and other are all pursuing deep geological disposal.

National Strategies

Finland

- The Onkalo repository is a deep geological repository expected to be large enough to accept canisters of spent fuel for around one hundred years, i.e. until around 2120 when the access tunnel will be backfilled and sealed.



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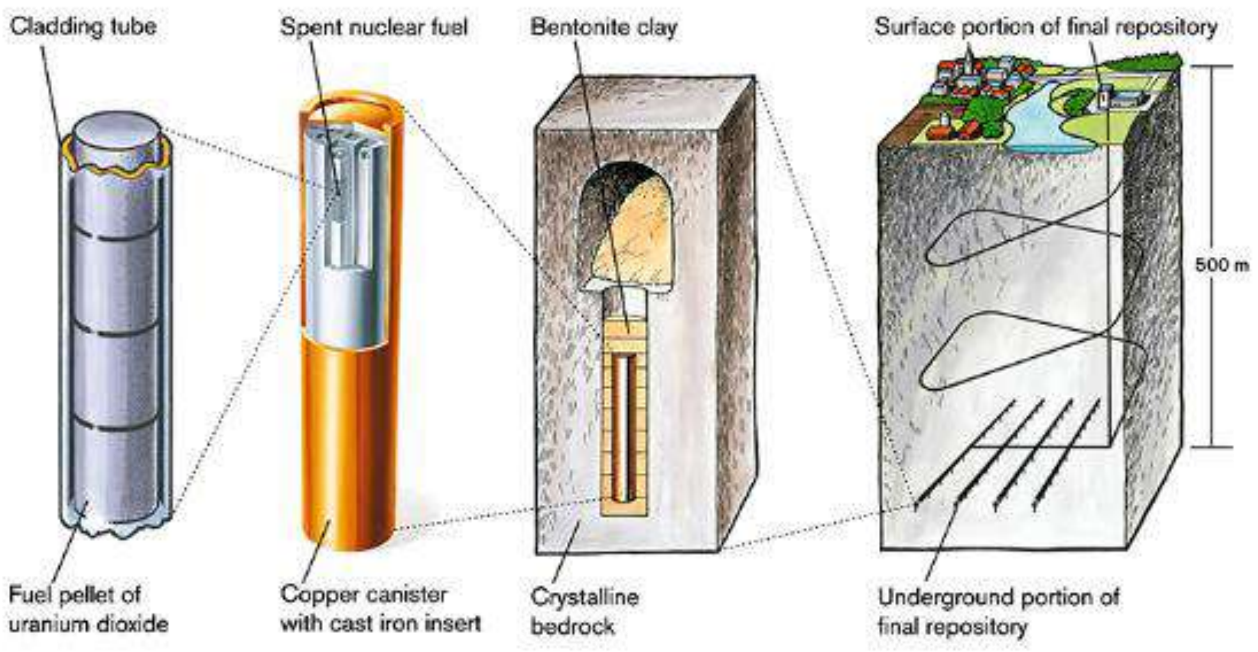
National Strategies - Sweden

- Is building a Spent Fuel Repository at Forsmark in Östhammars Municipality.
- Bentonite is a natural geological material that has been stable over timescales of millions of years and this is important as the barriers need to retain their properties for up to 10^6 y.



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National Strategies

<u>Germany</u>

- Currently, Germany does not have an operating radioactive waste disposal facility.
- The Morsleben disposal facility has stopped receiving waste and is being closed.
- A nationwide search has begun to find a site for a disposal facility that could receive various types of radioactive waste, including high level waste (HLW)

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National Strategies - UK

- Britain has been trying for years to secure a site with the right geology and local communities which would volunteer to host a £12bn geological disposal facility.
- In 2018, the UK issued an updated framework document called IMPLEMENTING GEOLOGICAL DISPOSAL – WORKING WITH COMMUNITIES.
- Britain's strategy relies on a willing host community.

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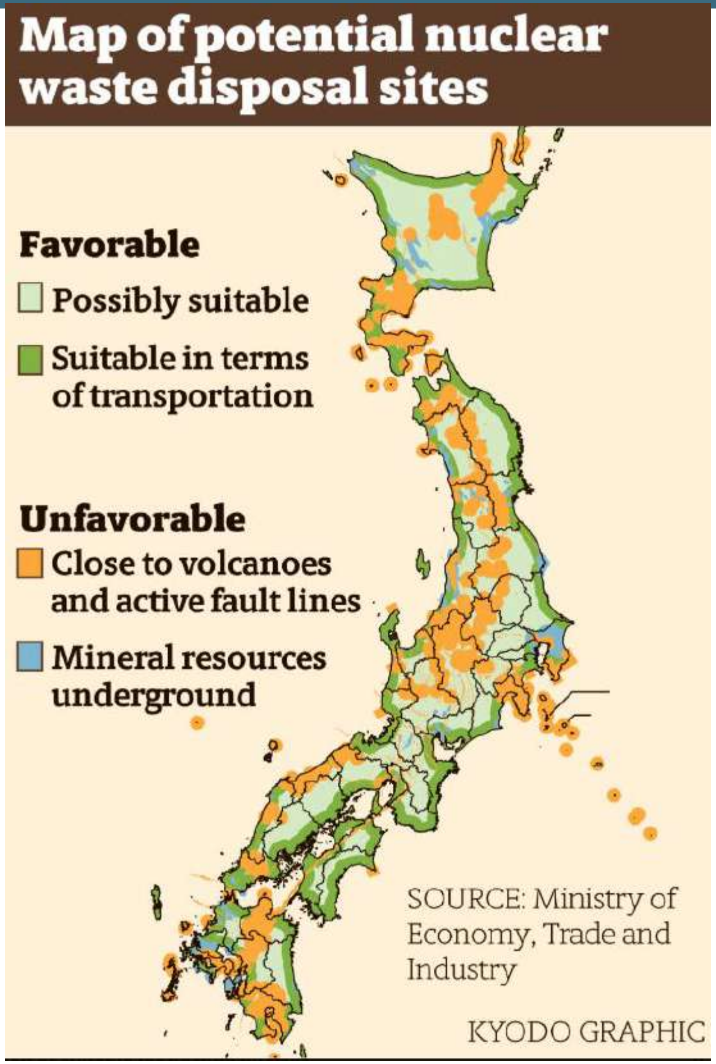
National Strategies

Japan

- Japan's situation is difficult because much of the country is seismically active.
- Nonetheless, the government is proceeding with a search for a suitable site.
- There is still a great mistrust of nuclear technology in Japan, and concern has been raised that the government is trying to force through a repository location.



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National Strategies - Canada

- There are two separate long-term radioactive waste management initiatives underway in Canada that may result in geological repositories.
- The NWMO APM initiative seeks to find a solution for the long-term management of used nuclear fuel – a solution that is socially acceptable, technically sound, environmentally responsible and economically feasible to Canadians.
- The Ontario Power Generation (OPG) Deep Geologic Repository (DGR) focuses on the disposal of low- and intermediate-level radioactive wastes at the Bruce Site in Tiverton, Ontario. The DGR will also hold waste produced from the continued operation of the Bruce, Pickering and Darlington nuclear power plants.

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Waste Burner Reactor – finally a viable solution to the waste issue?

- The waste burner uses existing high-level nuclear waste as its fuel, and is designed for those regions with existing stockpiles from their current nuclear fleets.
- It is fueled with uranium, plutonium and higher actinide trichlorides that have been derived from spent fuel from traditional thermal reactors, and hence is identified as a “waste burner”.
- Proliferation-resistant.
- MOLTEX is building a molten salt reactor in Canada in cooperation with New Brunswick Power.

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Considerations

- Should we think of spent nuclear fuel as waste, or as a valuable resource?
- The drivers are largely economic at this point.
- Very low fossil fuel prices make spent fuel worthless at this point in time, but that thinking will change as global warming is addressed and peak carbon is reached.
- Technology continues to improve, and waste-burner reactors could represent a game-changing paradigm shift.

Conclusion

At this point in time, temporary storage in spent fuel pools followed by dry-cask storage continues to make the most sense for new nuclear markets.

Do you agree?

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