Alternatives to the Burial of Low-Level Radioactive Waste

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Introduction

- Approach for management of LLRW in various countries has evolved differently due to many factors:
  - Culture and public sentiment,
  - Systems of government,
  - Public policy, and
  - Geography

Methods to Disposition LLRW

- Long-term storage and unconditional or conditional release of material
- Direct burial
- Treatment (Processing) → burial
- Treatment → Unconditional Release
- Recycle for Unconditional Release or Reuse Within Any Industry
- Controlled Recycle within Nuclear Industry

Drivers for LLRW Management Approaches

- Availability of Disposal Facilities (Most Important
- Disposal costs (fees)
- Financial resources
- Public acceptance
- Transportation availability

LLRW Disposal Options and Management Responsibilities

LLRW Management Approach	France (1)	Japan (2)	Germany (3)	Canada (4)	United Kingdom (5)	Sweden (6)	Spain (7)	Belgium (8)	Finland (9)	Switzerland (10)	Slovak Republic (11)	Hungary (12)	Mexico (13)	Netherlands (14)	Italy (15)	Australia (16)	Denmark (17)	Norway (18)	**Total Yes Count**
Disposal options are available for all LLRW	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	○	0
Disposal options are available for short-lived low- and intermediate-level radioactive waste	●	●	○	○	●	●	●	○	●	○	●	●	○	○	○	●	○	●	10
There are plans to build a LLRW disposal facility for short-lived low- and intermediate-level radioactive waste	○	○	●	●	●	○	●	●	○	●	○	●	○	○	●	●	●	○	10
Disposal options are available for long-lived low-level radioactive waste	○	NR	○	○	●	○	○	○	NR	○	○	●	○	○	○	○	○	○	2
A central organization (national nuclear regulatory authority or national waste management organization) is responsible for providing a waste disposal facility	●	○	●	○	●	○	●	●	○	○	●	○	○	●	○	NR	NR	●	9
A central organization (national nuclear regulatory authority or national waste management organization) is responsible for operating a waste disposal facility	●	○	●	●	○	○	●	●	○	●	○	●	○	●	○	NR	NR	○	8
A commercial waste management company is responsible for operating a waste disposal facility	○	●	○	○	●	●	NR	○	NR	●	NR	○	○	○	○	NR	NR	○	4
Disposal fees are or planned to be determined by a national fee schedule based on type of radioactive waste	○	○	●	NA	●	○	●	●	○	●	●	○	●	●	NA	NA	NA	●	9
Waste generators negotiate disposal fees based on type of radioactive waste	●	●	○	NR	○	○	NR	○	○	○	NR	○	●	○	NA	NR	NA	○	3

Source: GAO survey of foreign countries, 2006, and reported information on planned LLRW disposal facilities in IAEA and NEA country reports.

Legend: ● – Yes; ○ – No; NR – No response; NA – Not applicable

Note: Countries are ordered according to their nuclear electricity generation at the beginning of 2006, as reported by NEA. The last four countries in the table currently do not have nuclear electricity generation, but Italy did in the past, and the other countries have nuclear research reactors. The United States would be the largest nuclear electricity generator if listed.

Two Key Findings

- Wide variability as to the disposal options available in the countries noted
- No country surveyed by the United States GAO have disposal options for all LLRW

Burial Cost

- Attempted to perform International Survey of Burial Fees/Costs
  - Diligent follow-up on request was required
  - Some considered fees confidential due to competition
- Assertion – Burial is Expensive
- Should be considered a societal cost

Regulatory Issues

- Not a uniform set of clearance standards

  Effect ⬇

- Stakeholder concerns over material moving from one country to another
- IAEA Agreement of Principles provides some consistency for movement across country borders
  - Safety Series RS-G-1.7 “Application of the Concepts of Exclusion, Exemptions and Clearance” IAEA, 2004

Regulatory Issues - Transportation

- Recycling opportunities need to consider the international shipping requirements
- IAEA has developed regulations for the transport of radioactive material
  - IAEA Safety Series “Regulations for the Safety Transportation of Radioactive Materials, 1996 edition” (TS-R-1, ST-1 Revised)

Recycling Practiced Internationally

- USA
- France
- Germany
- Sweden
- UK
- Germany
  - 93% of the metal from a former BWR recycled most of it through unconditional release

Examples of Recycling Within the Nuclear Industry by Type of Material

- **Nickel**
  - Nickel good candidate for recycling due to its high demand and expense
  - Used for steam generator tube replacement and can be converted into Alloy 690
- **Lead**
  - Lead is currently extensively recycled within the nuclear industry
  - Lead is melted and used (and reused) as lead blocks for shielding purposes (shield walls
  - Blocks can be reused in the same facility or another facility

Examples of Recycling Within the Nuclear Industry by Type of Material (Continued)

- **Stainless Steel**
  - Although stainless steel is used extensively in the industry, not widely recycled within the industry
  - Recycle of decontaminated stainless steel into the public domain is undertaken in Sweden and elsewhere
- **Carbon Steel**
  - Due to its low value, the recycling of carbon steel is limited
  - Demand for production of a commonly needed item is necessary to make recycling economic

Examples of Recycling Within the Nuclear Industry by Type of Material (Continued)

- **Concrete**
  - Concrete is a prime material used in constructing common nuclear plants as well as other facilities
  - Material can be reused onsite as backfill for new plants or as an aggregate
- **Graphite**
  - In the UK alone, there is over 80,000 tons of graphite
  - Technical challenges in recycling graphite
  - Large potential for use exists:
    - Fuel components
    - Moderators
    - New reactors
  - Extensive study is being undertaken to determine safest and most cost effective methods for recycling

Specific Examples of Commercial Recycling

- **Contaminated Metals from the Nuclear Industry – Overview of the Studsvik Sweden Experience**
  - Since 1987, Studsvik has melted low-level scrap metal
    - Aim of safely determining the radioactive content of the metal after treatment in order to recover the metal for reuse
  - Minimize the final volume that needs to be disposed
  - Scrap metal mainly originates from nuclear installations
  - Installations mainly comprise nuclear power plants, nuclear fuel vendors and experimental facilities.

Specific Examples of Commercial Recycling (Continued)

- Studsvik RadWaste handled large components such as heat exchanger up to 150 tonnes each
- Upon arrival, metals were treated in order to decrease surface activity
- Metals blasted on the inside with the special tube blasting equipment
- Studsvik decontaminated, cut, melted and released material from two steam generators from PHWR in Agesta
- Following clearance, metals are remelted at steelworks or foundries operating outside the nuclear sector

Specific Examples of Commercial Recycling (Continued)

- **Radioactive Metal Recycling by Energy*Solutions***
  - Energy*Solutions* and British Nuclear (BNG) have demonstrated that low and intermediate-level radioactive metals can by recycled for beneficial reuse in a safe, regulatory-compliant, environmentally friendly and cost-effective manner.
  - Successfully obtained all required UK, U.S. and other international regulatory approvals
  - Completed the characterization, packaging and transatlantic transportation of 30 low- and intermediate-level waste pond skips.
  - Skips were packaged in polypropylene bags, loaded into one half-height ISO container and transported to a UK port and then to the U.S.

Specific Examples of Commercial Recycling (Continued)

- Delivered to Bear Creek Operations
- December 2006 melt campaign, recycled into ten-ton shield blocks for use in the nuclear industry
- Since 2008, continue to successfully recycle lead to meet the specifications of different customers for a variety of shielding configurations
- Since 1997, recycled over 5.9 million pounds of lead from the nuclear industry into various drum shield containers, brick, test weights, and custom shielding items

Energy*Solutions'* 20-ton, 7200 kW electric-induction furnace is the largest unit for melting and recycling radioactively contaminated metal in the U.S.

Shield blocks manufactured at Energy*Solutions* Bear Creek Facility.

Specific Examples of Commercial Recycling (Continued)

- **Recycling of Ore by International Uranium Corporation**
  - Five hundred tons of uranium-contaminated soil from the defunct Yurihama uranium mine in Japan sent to White Mesa Mill in southeastern Utah. Soil contamination in Japan was an issue
  - Japan does not have facilities to dispose of radioactive waste or by-products from the uranium enrichment process
  - The 10,150 cubic feet of contaminated soil shipped by truck from Everett to Utah’s White Mesa Mill where it was chemically processed into “yellowcake” for use as nuclear reactor fuel

Recycling Benefits the Environment

- Obvious environmental benefits to the decontamination, recycle and reuse of materials
- Benefits come primarily from the reduction of waste and eliminating the need to obtain fresh materials for the new product

Large Amount of LLRW Material Could Potentially Be Recycled

- To date, 100 mines, 90 commercial power reactors, over 250 research reactors and a number of fuel cycle facilities, have been retired from operation
- Most parts of a nuclear power plants do not become radioactive or are contaminated at very low levels and most metal can be recycled.
- Proven techniques and equipment are available to dismantle nuclear facilities safely

Implications for Decommissioning

- Not having a waste management option could delay decommissioning of nuclear facilities
- Availability of recycling for the waste may accelerate decommissioning progress
- With improving prospects for building new nuclear power plants, the industry would likely use the option if significant amounts of waste materials could be recycled economically

Conclusions

- Controlled recycling of LLRW materials within the nuclear industry has been demonstrated to be practical and economical
- Reuse of materials within the nuclear industry can properly address stakeholder concerns for material being used for what they believe to be improper purposes
- A mechanism to uniformly track material to show where material has been moved and ultimately dispositioned would contribute to enhancing the endorsement of controlled recycling
- Recycling is environmentally beneficial

Conclusions (Continued)

- In many cases recycling is cost beneficial as compared to other options to disposition the LLRW
- To further the advancement of controlled recycle countries must continue to embrace the concept
- Create large enough feedstocks of like type material to achieve economies of scale
- Large amounts of material exist that can have conditional release within the industry that assures consistent endorsement by stakeholders
- This material includes:
  - concrete,
  - lead,
  - carbon and stainless steel, and
  - graphite.

Conclusions (Continued)

- Little consistency exists in national approaches to recycling radioactive waste
- Many options exist for recycling to allow for the release of materials into the public domain (after decontamination to allowable levels)
- No uniform endorsement of recycling from country to country and some stakeholders do not agree with this type of material release (often referred to as unconditional release)
- More work needs to be done to ensure consistency in regulation from country to country
- IAEA work has been beneficial and needs to continue