Emerging Trends in the Nuclear Fuel Cycle: Implications for Waste Management – 9247

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ABSTRACT

There are emerging trends in the nuclear fuel cycle that have implications for waste management. This paper will discuss activities in both the front-end and back-end of the nuclear fuel cycle for the U.S. Nuclear Regulatory Commission (NRC)-regulated entities. Particular focus will be given to the front-end which includes uranium recovery facilities, conversion facilities, and enrichment facilities. The back-end activities include progress on the proposed high-level waste geologic repository at Yucca Mountain, NV and efforts to reprocess spent nuclear fuel or downblend HEU. While there are potential environmental impacts due to construction and dismantling of fuel cycle facilities, this paper focuses on the *operational* waste stream that will need to be managed as a result of fuel-cycle facilities.

OVERVIEW OF THE NUCLEAR FUEL CYCLE AND ITS WASTE STREAM

Much of the attention raised by the nuclear renaissance has been focused on building new nuclear power plants. However, before new reactors are able to come on-line, the required capability of the front-end of the nuclear fuel cycle (i.e., mining, milling, conversion, enrichment, fuel fabrication) must be in place. This section provides an overview of these stages (illustrated in Figure 1) and the major waste products associated with the nuclear fuel cycle. Due to the chemical properties of some of the waste products, it is possible to reprocess and reuse them in portions of the front-end of the fuel cycle, which is also discussed.

Uranium Recovery

Open pit or underground mining approaches have historically been applied to collect uranium ore, which is then sent to conventional mills for extraction. The crushed ore which remains after uranium is extracted, referred to as mill tailings, are placed in a constructed impoundment or the former mine pit. The Atomic Energy Act, Section 11e(2) defines “the tailings or wastes produced by the extraction or concentration of uranium or thorium from any ore processed primarily for its source material content” as byproduct material. Tailings are potentially harmful because they contain most of the original radioactivity existing in naturally occurring ore. While external exposure rates are low due to uranium’s long half-life and therefore low specific activity, the main risk stems from the possibility for inhalation exposure from radon gas and associated particulate daughter products that could be emitted from the dried tailings.

The existing inventory of mill tailings, as well as projected inventories from any future conventional mills, must be safely confined as required under the Uranium Mill Tailings Radiation Control (UMTRCA) Act of 1978. UMTRCA established two programs. Title I tasked the Department of Energy (DOE) for remediating pre-1978 abandoned mill tailings sites while Title II covers the sites licensed by NRC or an Agreement State after 1978. In both Title I and Title II sites, NRC has the authority to determine whether the mill tailings will be safely confined with the use of an embankment or a retention pit that meet the criteria in 10 CFR 40, Appendix A. There are 30 Title I tailings disposal sites ranging in size from 46,000 to 3.5 million cubic meters (60,000 to 4.6 million cubic yards) [1]. There were five

Title II sites managed by DOE in 2007, and there will ultimately be as many as 27 sites after their licenses terminate, including one former conversion facility under reclamation for 11e(2) byproduct material [2].

In the U.S., uranium recovery facilities are licensed by either the NRC or by Agreement States. There are no NRC-licensed conventional mills currently operating in the U.S., but it is likely that the one on stand-by (Sweetwater site in Wyoming) will resume operations. In Agreement States, there is a conventional mill under a Colorado source material license that is currently on stand-by status and is expected to operate again. In-situ Recovery (ISR), an alternative to conventional milling, is now a more widely-used process. There are two NRC-licensed operating ISR facilities and one NRC-licensed ISR facility on stand-by. In Agreement States, there are several ISR facilities operating in Texas. Using ISR, uranium is directly extracted from the earth by injecting the uranium deposits with solvents to dissolve and remove the uranium. ISR eliminates the need to dispose of the mill tailings, and greatly reduces the waste stream resulting from uranium recovery. The solid waste stream resulting from a typical ISR site is on the order of 100 m^3/yr (150 yd^3/yr)[1], and can be sent to an existing mill tailings impoundment, or to a licensed LLW facility for disposal. The liquid waste produced with ISR requires proper disposal because it has the potential to contaminate groundwater. Liquid wastes can be disposed of using deep well injection or evaporation ponds. Whether accomplished in conventional ways, or through ISR, the final product of uranium recovery is U_3O_3, referred to as yellowcake.

Conversion to Uranium Hexafluoride

Yellowcake is transformed into uranium hexafluoride (UF_6) in a conversion facility by producing liquid UF_6 that is cooled into a solid before shipment to an enrichment facility. The only operating conversion plant in the U.S. is Honeywell’s facility in Metropolis, Illinois. It is designed to produce 14,000 short tons of UF_6 from uranium concentrates. Annual waste products from this facility include 28m^3 of contaminated metal, 680 metric tons of fluorination ash, and 10 metric tons of dry active waste and roughly 3,220 metric tons of calcium fluoride (CaF_2). The fluorination reactor ash is partially recycled to recover some of the uranium and the CaF_2 can be sold commercially[3]. What cannot be sold on the commercial market will need to be disposed of as either nonhazardous solid waste or Low-Level Waste (LLW), depending on the classification of the waste form [4].

Enrichment

Enrichment is the process of increasing the concentration of the U_{235} isotope in the UF_6. For eventual use in power reactors, the uranium is enriched up to 5%. The main byproduct of enrichment is depleted uranium (DU), which can be in the form of depleted uranium hexafluoride (DUF_6), or depleted uranium oxide (UO_2 or U_3O_8). Due to the very long half-life of uranium and other parent radionuclides in the uranium series, the daughter products, such as Ra_{226}, are in secular equilibrium with their parent in naturally occurring ores. A large portion of the activity of mill tailings at the time of disposal is associated with the daughter product radium. Consequently, disposal options are based on the risk poised by the radiological inventory at the time of disposal [5].

DU, on the other hand, has a relatively higher concentration of the parent radionuclides and is relatively depleted of the daughter products compared to natural ore or mill tailings. For this reason, DU has the potential to produce larger concentrations of the daughter products over a long period of time compared to natural uranium or mill tailings, as ingrowth of the daughter products occurs. A study conducted by the NRC concluded that DU in oxide form, having approximately 99.9 percent uranium oxide at the time of

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[1] Based on the Crow Butte site in Chadron, Nebraska.

disposal, would have greater than 300,000 pCi/g Ra_{226} and Th_{230} approximately 1 million years after disposal [5]. This is compared to mill tailings that commonly have from 0.004 to 0.02 wt percent U_3O_8, 26 to 400 pCi/g Ra_{226}, and 70 to 600 pCi/g Th_{230} at the time of disposal [6] The physical characteristics of DU are important to waste management because the daughter radionuclides have different mobility in the environment than the parent radionuclides. There is 700,000 metric tons of legacy DU from the DOE operations at Portsmouth, Ohio and Paducah, Kentucky [7]. In addition there are two newly licensed enrichment facilities, whose future waste streams will be discussed in a later section of this paper.

Fuel Fabrication

The enriched UF_6 is chemically processed at a fuel fabrication facility into UO_2 powder and converted into pellets that can be used in fuel rods. There are currently 5 NRC-licensed uranium fuel fabrication facilities operating: the two AREVA NP, Inc. facilities in Lynchburg, Virginia and Richland, Washington, the Babcock & Wilcox Nuclear Operations Group in Lynchburg, Virginia, the Global Nuclear Fuel-Americas, LLC in Wilmington, North Carolina, and the Westinghouse Electric Company, LLC facility in Columbia, South Carolina [8]. The Nuclear Fuel Services fuel fabrication facility in Erwin, Tennessee is planning to apply for a 20-year renewal to its license that expires July 31, 2009. In 2007, Westinghouse and BWX Technologies received 20-year license renewals from the NRC [9].

The solid LLW products of fuel fabrication include contaminated packaging materials or equipment, floor sweepings, filters, incineration wastes, and sludges or residues from chemical processes. Solid waste is processed to recover the uranium and collected in containers for disposal. The amount of solid waste requiring disposal varies from facility to facility, depending on production. For example, the Westinghouse Columbia Fuel Fabrication Facility recorded 45,000 kg to 270,000 kg (100,000 lbs to 600,000 lbs) of solid LLW between the years of 1996 and 2003 [10].

Reprocessing and Final Disposition

Spent nuclear fuel can be reprocessed to chemically separate the uranium and plutonium from the fission waste products. The recovered Pu_{239} can be used along with U_{235} in new fuel assemblies. Currently there are no commercial reprocessing facilities operating in the U.S., but there has been renewed interest in reprocessing in recent years. Spent nuclear fuel and other waste produced from reprocessing are classified as High-Level Waste (HLW) and must be disposed of in a geologic repository as required by the Nuclear Waste Policy Act as Amended (NWPA). NRC is currently reviewing the license application submitted by DOE for the proposed HLW repository at the Yucca Mountain site in Nevada. However, the projected opening date for the repository has once again been delayed, this time until 2020. Congress has cut funding this year for project and the new administration has expressed that it is not supportive of the project.

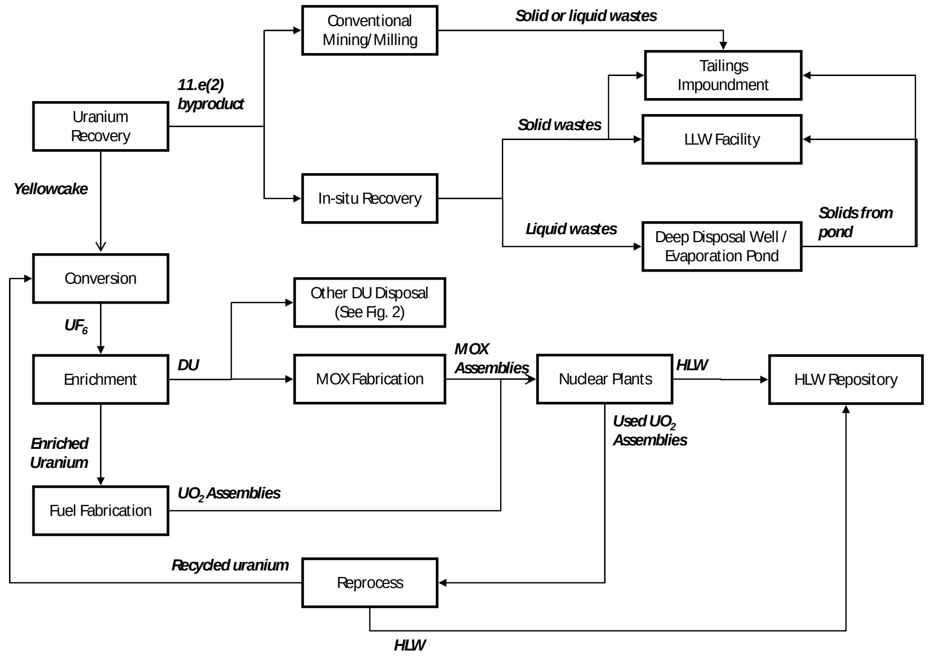

Fig. 1 Overview of the Nuclear Fuel Cycle Waste Stream

EMERGING TRENDS IN THE FRONT-END OF THE FUEL CYCLE

Recent trends in the front-end of the nuclear fuel cycle have implications for long-term management of the nuclear fuel waste stream. The national security threat associated with foreign import of energy fuels and increased attention to climate change has poised nuclear power as an attractive energy source, increasing market activity surrounding future fuel supplies. In response, interested associations and stakeholders are preparing for future growth. Meanwhile, DOE might be able to sell its excess uranium and depleted uranium on the market [11]. This, along with imported uranium that has been blended down from Russian weapons built during the Cold War could increase supply, thereby decreasing domestic demand for enriched uranium and reducing the amount of DU that is created. Complicating future decisions regarding waste management is the uncertainty in disposal capacity for Class B and C waste, as well as factors affecting the classification of DU. These matters are summarized below.

Uranium Market Activity

Hedgefund dollars and general speculation have greatly influenced the uranium spot price in recent years. Since 2004, the price has increased from \$20/lb to a peak price of \$135/lb in August 2007 [12]. More recently, partially due to current economic turbulence, the price has declined to \$55/lb[2]. However, even with the recent dip in the spot price, there is still a growing interest in expanding production capacity of the front-end of the fuel cycle. Ux Consulting indicated in late 2008 that the recent liquidation by hedge funds has slowed relative to new buying. Furthermore, Desutsche Bank Commodity Services LLC and New York Nuclear Corporation have expressed interest to the U.S. Securities and Exchange Commission to launch a uranium fund whose share price could act as an alternative to the spot market. The DB-New York Nuclear Uranium Fund would differ from existing closed-end funds such as Uranium Participation

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[2] Based on December 3, 2008 spot price.

Corp. and Nufcor Uranium Ltd in that the shares could be redeemed for actual uranium [9]. This fund could help stabilize volatility in the market, increasing its attractiveness to investors.

New and Restarts in Domestic Uranium Recovery

In anticipation of rising demand, domestic uranium recovery and enrichment is increasing. In the U.S, there are currently three NRC-licensed ISR facilities and one NRC-licensed conventional mill. Also, there are several uranium recovery sites licensed by Agreement States [13]. NRC is expecting to review applications for as many as 28 new, restart, and expansion uranium recovery applications by 2012. These applications are for conventional, heap-leach, and in-situ recovery sites in Arizona, Nebraska, New Mexico, South Dakota and Wyoming. In FY 2008, NRC received all four of the expected applications. Currently, 6 of the 28 applications are for conventional mills [14]. The fact that the majority of the new facilities will be ISR as opposed to conventional mills reduces the potential waste streams resulting from uranium recovery. While industry has suggested that timelines for new facilities may be slightly delayed due to the recent credit crunch, almost all have indicated that plans are still moving forward.

Cooperation on Safety and Environmental Impact of Uranium Recovery

As a result of growing international interest in uranium recovery, the International Forum on Sustainable Options for Uranium Production (IFSOUP) was founded to promote the safe, sustainable production of uranium. The inaugural meeting of the International Forum on Sustainable Options for Uranium Production was held in Phoenix, Arizona on February 26, 2008, as a separate forum during Waste Management 2008. Among those in attendance were representatives from the uranium industry, industry associations, international agencies, the regulatory community, educational institutions, and nongovernmental organizations.

The National Mining Association held its Annual Uranium Recovery Workshop in Denver, Colorado, to discuss licensing issues, and other uranium recovery topics of interest. Over 250 representatives from industry, Federal and State agencies, Indian Tribes, and stakeholders attended the 2008 Workshop. Immediately prior to the workshop, IFSOUP and the International Institute for Indigenous Resource Management (IIIRM) arranged a meeting for Tribal, industry and agency delegates to discuss with members of industry and NRC what the Tribal delegates regarded as attributed of sustainable uranium production. This was a rare opportunity for the parties to meet outside of the context of formal scoping or comment meetings, to discuss these issues. Importantly, it highlighted the promise and benefits of meeting to achieve common goals. Many of the tribal delegates remained for the full Workshop that followed by sharing experiences and insights with the industry and agency participants.

New Build and Expansions of Enrichment Facilities

NRC has licensed two new enrichment facilities in the last two years: The Louisiana Energy Services (LES) National Enrichment Facility (NEF) in New Mexico and the USEC American Centrifuge Project (ACP) in Ohio [15]. The agency is expecting two license applications for new facilities in 2009. AREVA is planning a centrifuge facility near Idaho Falls, Idaho, and Global Laser Enrichment (GLE) (a subsidiary of GE-Hitach Nuclear Energy) is planning an enrichment facility in Wilmington, North Carolina. Although the laser technology is new, the process does not produce new types of hazardous wastes or materials [16]. The amount of DU expected from the laser enrichment technology is comparable to that of the centrifuge and gaseous diffusion process.

LES recently announced plans to increase capacity of NEF from 3 million separative work units (MSWU) to 5.9 MSWU. Although USEC is licensed for 3.8 MSWU, the Final Environmental Impact Statement (FEIS) assumed 7 MSWU, so an expansion for that facility is also possible [15]. The AREVA application is expected to be for a 3 MSWU facility and the GE application is expected to be for a 3.5

MSWU to 6 MSWU facility [16]. There is currently over 700,000 metric tons of DU that needs a disposition path resulting from DOE's activities at Portsmouth and Paducah. This figure is increased to over 1 million metric tons due to the licensing of USEC ACP and LES NEF.[3] Considering the additional future waste streams from the possible expansion of ACP and NEF, as well as the new GE Silex and Areva facilities, this amount is increased to approximately 2.1 million metric tons.[4] In addition to DU, the new enrichment facilities will increase the amount of LLW that needs disposal. For example, NEF is projected to produce about 87,000 kg of LLW annually for its operational lifetime of 30 years (2,600 metric tons) [15].

Factors Affecting the Disposition of Depleted Uranium

Based on 10 CFR 61.55(a)(6), DU is defined as Class A LLW [17]. Still, DU is distinguishable from other types of commercial LLW in that a large portion of the present-day radioactivity is associated with the long-lived parent radionuclides. As radioactive decay occurs, increasing hazard results from the larger concentrations of decay products that have faster transport times through the subsurface. This characteristic contrasts with many other commercial LLW products, which represent a decreased hazard over time. Due to the large quantities of DU that will need to be disposed, and because it has properties that are dissimilar from other types of commercial LLW, the NRC is currently evaluating various regulatory options for DU. DUF_6 can be stored for up to 40 years. If DUF_6 is converted to U_3O_8, it can be stored for longer periods of time. Conversion could take place at DOE conversion sites in Piketon, OH or Paducah, KY or at a private fuel fabrication facility [11]. Hydrogen fluoride gas is a main byproduct of the conversion process. This gas can be dissolved in water to form aqueous hydrofluoric acid (HF). Aqueous HF can potentially be made into anhydrous HF through a distillation process, which has more commercial uses than in the aqueous form. HF is used in common industrial processes and can be sold commercially. Alternatively, HF could be converted to calcium fluoride (CaF_2), which can also be sold commercially [15]. Figure 2 outlines the possible alternative disposal paths for DU. While there are a number of options for possible conversion and reuse of DU, what is not reused will need to ultimately be disposed.

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[3] Draft Supplement Analysis for Locations to Dispose of DU Conversion Product Generated from DOE's Inventory of DUF_6, (DOE/EIS-0359-SA1 and DOE/EIS-0360-SA1), March 2007 at p. 43; FEIS for the Proposed National Enrichment Facility in Lea County, New Mexico, NUREG-1790, June 2005 at p. 2-27; FEIS for the Proposed American Centrifuge Plant in Piketon, Ohio, NUREG-1834, April 2006) at p. 4-51.

[4] Figure is based on 3 MSWU for the GE and AREVA facilities and approximately the same DU production per SWU and lifetime as the NEF facility. This is a conservative figure because the GE facility may be up to 6 MSWU.

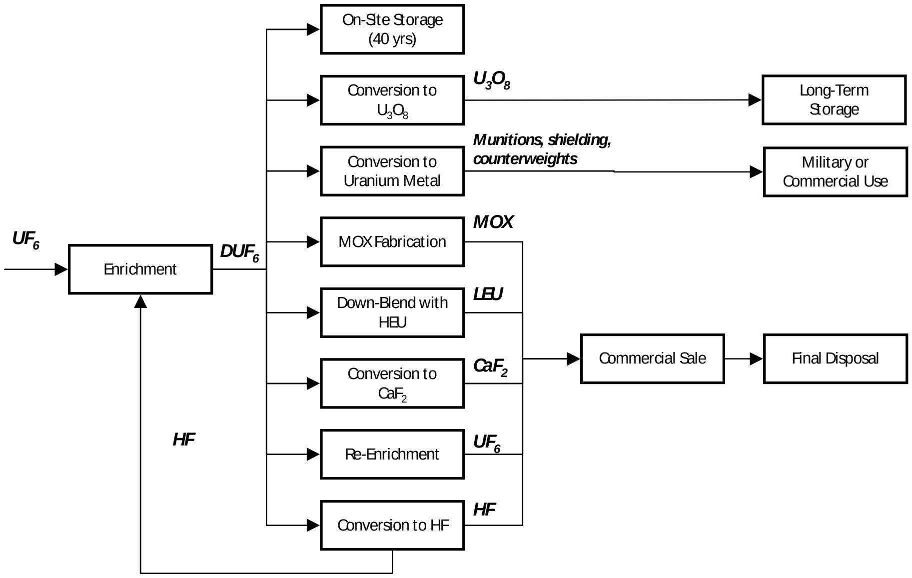

Fig. 2. Possible Alternative Disposal Paths for Depleted Uranium

While DU is a Class A LLW, it is not clear in which of the current LLW facilities it will be disposed. NRC staff has analyzed several options for regulatory options concerning disposal of depleted uranium. In the Commission paper responding to the Commission Order CL-05-20 regarding depleted uranium, the staff recommended to proceed with rulemaking in 10 CFR Part 61 to specify a requirement for a site-specific analysis for the disposal of large quantities of DU showing that the performance objectives in subpart C to Part 61 can be met. These performance objectives are: protection of the general population from releases of radioactivity, protection of individuals during operations, protection of an inadvertent intruder, and stability of the site after closure. Certain technical requirements (e.g., type of receptors, exposure scenarios, period of performance) will also be specified. Staff also recommended development of guidance documents outlining the parameters and assumptions to be used in conducting such site-specific analyses. The technical parameters that will be considered in such analyses include the type a quantity of material to be disposed of, as well as specific environmental characteristics of the site [17].

The potential requirement to perform a site specific analysis will be important given the 700,000 metric tons of DU at the DOE sites, and the future projections of approximately 1.4 million metric tons that will result from the expanded and newly licensed enrichment facilities. The large volume of DU that will eventually need disposal, combined with the uncertainty in its final disposal location, reinforces the need for a site-specific analysis. Existing and proposed disposal facilities have expressed interest to their Agreement State regulators in disposing of large quantities of DU. Potential disposal facilities are outlined in the following section.

Future Capacity of LLW Disposal Facilities

In 1980, Congress granted the states the right to form regional contracts in order to dispose of LLW produced by states within the Compact and to restrict access. Since this law was enacted, no Compacts have licensed and constructed disposal facilities, and LLW disposal capacity remains a contentious issue. The three operating facilities are: *EnergySolutions* Barnwell Operations in Barnwell, South Carolina, U.S. Ecology in Richland, Washington, and *EnergySolutions* Clive Operations in Clive, Utah [18]. Just as an increased production of DU or other LLW will impact waste management, the availability of disposal capacity for such waste streams will influence future decisions regarding the nuclear fuel cycle and the siting of new disposal facilities.

Barnwell accepts Class A, B and C wastes, but only from the Atlantic Compact States (Connecticut, New Jersey, South Carolina). As of July 2008, Barnwell stopped accepting waste from outside Compacts, eliminating a disposal option for Class B and C waste for 36 states. Approximately 560 to 700 cubic meters (20,000 to 25,000 cubic feet) of Class B and C LLW is disposed of annually at Barnwell [19]. Only about 5% of Class B and C waste consists of non-reactor waste streams from industrial, research or medical licenses (including fuel cycle facilities). In anticipation of Barnwell's closure, NRC updated its guidance regarding extended onsite storage of LLW for the non-reactor licensees. The guidance was provided to the non-reactor licenses and the 35 Agreement States [20].

The *U.S. Ecology* disposal site only accepts waste from the 11 states in the Northwest and Rocky Mountain Compacts (Washington, Oregon, Idaho, Montana, Wyoming, Utah, Alaska, Hawaii, Nevada, Colorado, New Mexico). Since the LES NEF is in New Mexico, this is a potential disposal option for NEF's DU.

The *EnergySolutions* facility in Clive, Utah is not limited to accepting waste from a certain number of Compacts, but is only able to accept Class A waste. The projected lifetime of this facility is 33 years [19]. However, this estimate did not consider the potential importation of large volumes of foreign countries' LLW. *EnergySolutions* is currently seeking the ability to accept 20,000 metric tons of LLW from Italy. The waste would be processed at its facilities in Tennessee and the waste would be disposed of in Clive, Utah. The company has applied for an NRC permit to import the foreign waste, as well as to export some of the residual waste back to Italy. In reviewing the application for the permit, NRC considers if there exists an appropriate facility that has agreed to accept the waste. The States of Tennessee and Utah do not object to the proposed import of waste; however, the Northwest Compact argues that *EnergySolutions* needs Compact approval. A lawsuit is still pending in which *EnergySolutions* has challenged the Compact's stated authority, and a group of stakeholders have requested an NRC hearing on the import/export license. In October 2008, the NRC issued an Order to defer the ruling on a hearing request until, "(1) a court makes a final determination in *EnergySolutions'* lawsuit; (2) *EnergySolutions* and the Northwest Compact reach an agreement on storing low-level radioactive waste at the Clive, Utah facility; or (3) the matter is otherwise resolved" [21].

Waste Control Specialists (WCS) has proposed a LLW facility for Class B and C waste in Andrews County, TX near the existing hazardous waste facility. The facility is currently authorized to dispose of wastes covered under the Resource Conservation and Recovery Act (RCRA), the Toxic Substances Control Act (TSCA), and the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as well as exempt quantities of radioactive waste, and byproduct 11e(2) material. The facility is also authorized to treat and store certain types of LLW and mixed LLW.

In May 2008, the Texas Commission on Environmental Quality (TCEQ) issued a license to WCS to dispose of radioactive byproduct material at its facility in Andrews County, allowing it to dispose of residues left over from mining, including mill tailings, as well as equipment used to process mill tailings

[22]. In November 2008, the TCEQ requested that the Texas Attorney General's Office move forward with efforts to secure mineral rights for WCS. The State of Texas requires 100% mineral rights ownership before a LLW disposal site license can be issued [23]. For WCS to be able to accept LLW outside of the Texas Compact (Texas and Vermont), the private facility would need approval from the State of Texas, the Texas Compact, and the state that is exporting the waste to WCS [15]. The excavated capacity of the LLW disposal facility is approximately 4 million cubic meters (5.4 million cubic yards) [24]. In an October 28, 2008 letter, NRC approved of TCEQ granting an exemption to WCS from the government land ownership requirements for the Federal facility so that the company could retain ownership of the disposal site until decommissioning. The NRC letter also supported TCEQ’s decision to prohibit DU from being disposed of by WCS under the initial license, which is important considering WCS’s interest in disposing of large quantities of DU.

Increase in Capacity of Mixed Oxide Fuel Production

One potential reuse of DU that could decrease the amount of DU that needs disposal is Mixed Oxide Fuel (MOX). DOE is planning a Mixed Oxide Fuel Fabrication Facility (Shaw AREVA MOX Services) at the DOE Savannah River Site (SRS) in Aiken, SC. NRC issued Construction Authorization in March 2005. NRC is currently reviewing the operating license application that was submitted November, 2006. Construction is planned to be completed by 2014, with operations starting in 2016 [25]. The MOX fuel fabrication facility has the potential to utilize some of the DU resulting from enrichment by blending it with plutonium oxide from Russia. The facility will have the annual capacity to utilize 3.5 tons of plutonium oxide and 125 metric tons of DUF_6 to produce approximately 60 MOX fuel assemblies per year. Capacity is based on processing a total of 34 metric tons of surplus plutonium over a 10 year lifetime [26].

Blending Down HEU to LEU

A factor impacting the available supply of enriched uranium, and thus future need for expansions of domestic production, is the blending down of high-enriched uranium (HEU) into low-enriched uranium (LEU). Under the “Megatons to Megawatts” program, HEU from dismantled Russian nuclear warheads is downblended into LEU to produce fuel for U.S. nuclear power plants. The program, set to expire in 2013, will convert 500 metric tons (MT) of Russian HEU over 20 years [27]. This produces approximately 10,800 metric tons (24 million lbs) of LEU [12].

Congress passed U.S. legislation (a revision to the Russian Suspension Agreement) in November 2008 in attempt to provide incentives for Russia to downblend additional quantities of HEU after the agreement expires in 2013. The legislation links the U.S. import quota for Russian LEU to the post-2013 downblending. It also grants direct access to the U.S. market, overcoming current restrictions to sell only through USEC, the U.S. executive agent for the agreement. If Russia agrees to downblend another 300 metric tons, the amount of LEU the program is permitted to supply to the U.S. will increase from 20% to 25% of the domestic requirements [28].

CONCLUSION

There are indications that the front-end of the fuel cycle is gearing up in preparation for the nuclear renaissance. This is supported by the applications that have been received for future uranium recovery sites, new and expanded enrichment facilities, and the MOX fuel facility. Still, many uncertainties exist in how these trends will impact nuclear waste management. The economic crisis may delay availability of new fuel cycle facilities as well as new power plants. The politics of the new administration may result in decreased support for licensing Yucca Mountain, but may also result in increased support for reprocessing spent nuclear fuel. Lack of the HLW geologic repository may provide incentive to increase the nation's use MOX fuel. Meanwhile, the availability of LLW disposal facilities continues to be a controversial issue, and the Italian Import Case may set precedence for other import actions.

These U.S. trends and impacts are part of the larger global system. Uranium is a globally traded commodity that is heavily influenced by the capital market and subject to import/export laws. Countries that lack their own enrichment capacity may wish to purchase fuel from U.S., further increasing demand for enriched uranium. Also, the potential for nuclear growth in India, Russia, China, and other countries may increase demand for global fuel supply. Industry, policymakers, and regulators will need to take into account the interrelated nature of these emerging trends when making future decisions regarding waste management.

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