Nuclear Waste Assessment System for Technical Evaluation (NUWASTE): Status and Initial Results

A Report to the U.S. Congress
and the Secretary of Energy

U.S. Nuclear Waste Technical Review Board
June 2011

Topical Report #2

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UNITED STATES
NUCLEAR WASTE TECHNICAL REVIEW BOARD
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June 2011

The Honorable John A. Boehner
Speaker of the House
United States House of Representatives
Washington, DC 20515

The Honorable Daniel K. Inouye
President Pro Tempore
United States Senate
Washington, DC 20510

The Honorable Steven Chu
Secretary
U.S. Department of Energy
Washington, DC 20585

Dear Speaker Boehner, Senator Inouye, and Secretary Chu:

The U.S. Nuclear Waste Technical Review Board submits this report, *Nuclear Waste Assessment System for Technical Evaluation (NUWASTE): Status and Initial Results*, in accordance with provisions of the 1987 amendments to the Nuclear Waste Policy Act (NWPA), Public Law 100-203, which direct the Board to report its findings and recommendations to Congress and the Secretary of Energy at least two times each year. Congress created the Board to perform ongoing independent evaluation of the technical and scientific validity of activities undertaken by the Secretary of Energy related to implementing the NWPA.

This report describes work being performed by the Board to evaluate the effects on the management of spent nuclear fuel and high-level radioactive waste of various fuel-cycle options being considered by the U.S. Department of Energy (DOE). Of particular interest to the Board are the types and quantities of the radioactive waste streams that would be generated. The Board has developed a computer-based systems analysis tool (NUWASTE) to support its technical evaluation of DOE activities in this area. Included in the report are initial findings from NUWASTE analyses.

The Board looks forward to continuing to provide useful independent technical and scientific information to Congress and the Secretary that can be used to inform the decision-making process.

Sincerely,

B. John Garrick
Chairman

con272vF

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Authors

This report presents results from work completed as part of the U.S. Nuclear Waste Technical Review Board's analysis of the impact of alternative fuel-cycle initiatives on the generation of spent nuclear fuel and high-level radioactive waste. The effort is led by Dr. Mark D. Abkowitz, Board member. This report was prepared by Mr. Nigel Mote, Mr. Gene W. Rowe, and Dr. Bruce E. Kirstein, members of the Board's staff.

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Nuclear Waste Assessment System for Technical Evaluation (NUWASTE): Status and Initial Results

Summary

The U.S. Nuclear Waste Technical Review Board (Board) has developed a computer-based systems analysis tool called the Nuclear Waste Assessment System for Technical Evaluation (NUWASTE). The Board intends to use NUWASTE to support its ongoing technical evaluation of U.S. Department of Energy (DOE) activities related to the management of spent nuclear fuel (SNF) and high-level radioactive waste[1] (HLW). Initial analyses performed using NUWASTE have demonstrated its value in gaining a better understanding of the effects of potential fuel-cycle initiatives on the generation of SNF, HLW, and other waste streams. A particularly important feature of NUWASTE is its ability to compare results for a range of scenarios and quantify the relative impacts on the program for managing SNF and HLW in the United States.

NUWASTE currently is designed to assess alternative fuel-cycle scenarios for the existing fleet of U.S. light-water reactor (LWR) nuclear power plants and the additional LWRs for which license applications have been submitted to the U.S. Nuclear Regulatory Commission (NRC). The initial focus of the NUWASTE analyses has been on the management of the SNF generated by those LWR plants, including dry storage, direct disposal in a repository, and the potential introduction of reprocessing with recycling of uranium and plutonium.

1. A glossary of technical terms and abbreviations is provided at the end of this report.

This report presents the results of analyses performed on four scenarios for managing SNF and HLW. The results reinforce the need for a deep geologic repository for disposal of both SNF and vitrified HLW in the United States and demonstrate that the timing of the availability of such a repository will fundamentally affect the need for additional SNF storage capacity. The results also show that, for the existing LWR fleet and the additional LWRs being considered by the NRC, the reprocessing scenarios considered here would have limited benefit in reducing the demand for natural uranium and limited benefit in reducing the volume of SNF and HLW, while significantly increasing the amount of low-level radioactive waste requiring disposal.

The Board is considering ways to extend this analysis and increase the scope and functionality of NUWASTE. This effort includes evaluating additional LWR scenarios and adding the capability to show the relative effects of different scenarios on program costs and operational timelines. Longer-term plans include expanding the capability of NUWASTE to consider implications for SNF and HLW management of introducing advanced thermal and fast reactors, alternative reprocessing technologies and away-from-reactor storage facilities, disposal of all DOE-owned SNF and HLW, and transportation requirements at each stage of the fuel cycle. As these developments are implemented, the Board will continue to report the results of its analyses to Congress, the Secretary of Energy, and the interested public.

Introduction

The U.S. Nuclear Waste Technical Review Board[2] (Board) was created as an independent agency in the Executive Branch in the 1987 amendments to the Nuclear Waste Policy Act (NWPA). The Board's statutory responsibility is to conduct an independent and ongoing evaluation of the technical activities undertaken by the U.S. Department of Energy (DOE) in managing commercial, research, and defense-related spent nuclear fuel (SNF) and high-level radioactive waste (HLW) and to report its findings and recommendations to Congress and the Secretary of Energy.

This report describes work being performed by the Board to evaluate the effects of the various fuel-cycle options being considered by DOE on the management of SNF and HLW. Of particular interest to the Board are the types and quantities of the radioactive waste streams that would be generated.

To support its technical evaluation of DOE's work in this area, the Board has developed the Nuclear Waste Assessment System for Technical Evaluation (NUWASTE), a computer-based systems analysis tool having the capability to analyze different scenarios and to compare the results. The initial focus of the work undertaken using NUWASTE has been on management of SNF from the existing and planned light-water reactors (LWR), including the potential introduction of reprocessing, and the recycling of uranium and plutonium in the same population of reactors. Coupled with this focus is consideration of the extent to which the potential benefits of reprocessing and recycling could currently be realized in practice in the United States. This is fundamental in assessing SNF inventories, reprocessing and recycling options, the radioactive waste streams that would be

2. Board members are nominated by the National Academy of Sciences and appointed by the President to four-year terms. Members are supported by a full-time technical and administrative staff headquartered in Arlington, Virginia.

generated, and the impact on demand for natural uranium. Subsequently, the analysis will be expanded to include other reactor technologies and the associated options for managing SNF and HLW.

The Board is aware that other institutions, including universities, National Laboratories, and private firms, are interested in developing, and, in some cases, already have developed, related analytical methods. However, the Board's approach is designed to provide an independent capability for evaluating the options being considered by DOE. This approach focuses on the impact each option would have on the types and quantities of radioactive waste generated by the U.S. nuclear power program as a whole, in line with the Board's technical review mission.

Development of Systems Analysis Capability

Early in 2009, the Board recognized the need for the capability to analyze the effects of new options for managing SNF and HLW being considered by DOE on issues such as the following:

- the need for dry storage of SNF at nuclear power plants
- the volumes of SNF and HLW that would require disposal in a repository
- the reduction in uranium demand that would result from recycling uranium and plutonium separated by reprocessing
- the introduction of new waste streams from different fuel-cycle technologies

The Board also knew that other factors must be taken into account, such as the timescale for completing the disposition of the SNF discharged from the existing and currently planned LWRs, and the economic implications. This led to the development of NUWASTE.

NUWASTE presents material-balance results for the entire U.S. nuclear power program. In this respect, it is different from most other available analytical tools, which are focused mainly on particular reactor types, management of a limited quantity of the SNF that will be discharged, or the effect of a particular process technology.

NUWASTE currently includes data on the complete U.S. fleet of operating and presently planned LWRs and all of the fuel-cycle operations needed to produce new fuel and manage SNF.[3] It also projects the quantities of waste of each type generated from reprocessing. A wide range of SNF management strategies, nuclear generation capacities, and fuel-fabrication alternatives can be represented. For example, the start date, capacity, and operating periods of the SNF management and waste disposal facilities can be specified, along with fuel burn-ups and the order of selection of SNF for disposal and reprocessing. NUWASTE also has the capability to apply importance-weighting to different waste management impacts when comparing the implications of alternative SNF and HLW management scenarios.

3. Where fuel-cycle services are currently provided by companies operating in the nuclear fuel markets on a commercial basis, no facility capacities or limits on availability are included in NUWASTE. Where new facilities would need to be constructed to allow the introduction of services that are not currently available, the facility capacities, and the timelines on which they could realistically be expected to be brought into service, are included in NUWASTE.

Figure 1 presents a schematic of the LWR fuel-cycle operations that NUWASTE currently is designed to address, including the recycling of plutonium and uranium in LWRs[4] and the wastes that are generated. Each icon represents a facility, and each arrow represents a potential transportation operation.

From examination of Figure 1, two important points become apparent. First, the nuclear fuel cycle and waste management facilities form a complex, interdependent system in which fuel-cycle decisions can have a profound effect on, and be affected by, waste management options. Second, a large number of LWR scenarios can be defined by a unique combination of facility capacities and operating timescales, the corresponding transportation logistics and operations, and the assumptions that underlie them.

Preliminary Analyses

For demonstrating NUWASTE functionality and illustrating the waste-related effects associated with different SNF and HLW management options, the results of four potential scenarios are used as the basis for the discussions in the following sections.

Each scenario assumes the following:

- The U.S. nuclear power plant fleet includes the existing nuclear power plants plus the 25 plants for which license applications have been submitted to the U. S. Nuclear Regulatory Commission (NRC).
- Each reactor has an operating life of 60 years, including lifetime extensions.

4. At present, NUWASTE does not include the waste generated during processing of uranium ore to produce uranium hexafluoride, because this varies according to both the source of the uranium ore and the extraction technology used and is thus not dependent only on the fuel-cycle option selected. However, consideration is being given to adding this waste stream to NUWASTE in the near future.

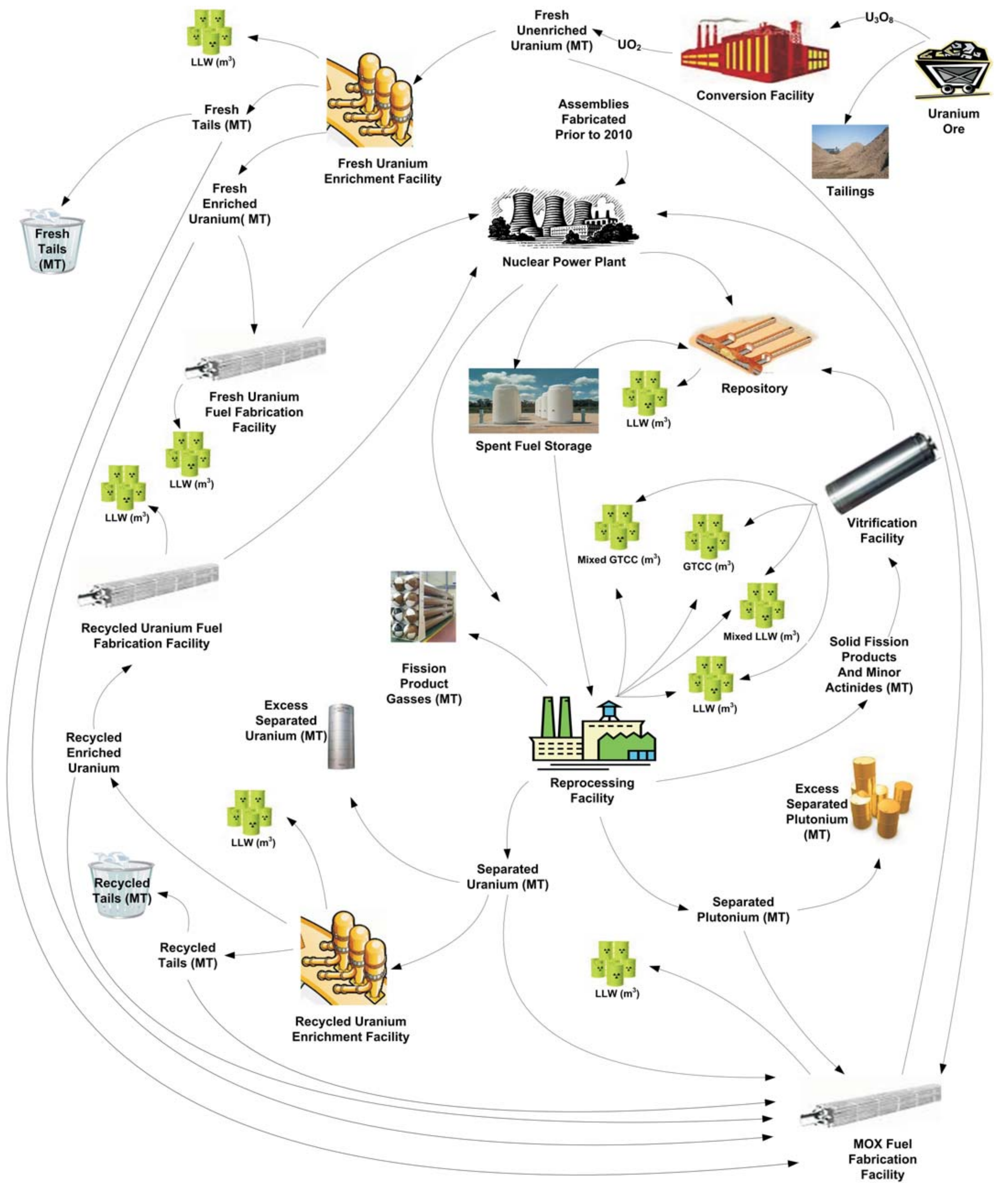

Figure 1. Process Operations and Material Flows Currently Included in NUWASTE

- Fuel burn-up for fuel assemblies discharged before 2010 was 40 GWd/MT.
- Fuel burn-up for fuel assemblies discharged in 2010 and beyond will be 60 GWd/MT.

Scenario Definitions

The four scenarios analyzed here are defined as follows:

Scenario 1: Long-Term Storage Only

- No repository
- No reprocessing facility

Scenario 2: Direct Disposal of SNF

- Repository operation starting in 2040 with a capacity of 3,000 MT/year
- No reprocessing facility

Scenario 3: Recycling of Uranium and Plutonium

- Reprocessing operations starting in 2030 with a capacity of 1,500 MT/year
- Repository operations starting in 2040 with a capacity of 3,000 MT/year
- Recycling of reprocessed uranium and plutonium once, following separation during reprocessing[5]
- All separated uranium and plutonium recycled within one year

Scenario 4: Recycling of Plutonium Only

- Same as Scenario 3 except that the separated uranium is not recycled

5. The value of the uranium and plutonium for production of new fuel decreases each time they are recycled. For this analysis, it is assumed that neither will be recycled more than once.

It is important to recognize that these scenarios are just four of many that can be represented and evaluated using NUWASTE. They were selected because they represent concepts that have been widely discussed as options for managing the nuclear fuel cycle and radioactive wastes from the current fleet of LWRs in the United States. In addition, where reprocessing is included, the reprocessing capacity was selected to allow for all of the separated plutonium to be recycled in the LWRs before the end of their operating lifetimes, without leaving any in storage that might present a proliferation risk. The Board is planning to evaluate other scenarios to gain a better understanding of the sensitivity of the analysis results to different program characteristics, such as facility capacities and operating schedules.

Methodology

The base module of NUWASTE includes a data library that records the relevant specifications[6] of all commercial nuclear power plants currently operating in the United States, those that have been permanently shut down, and those for which license applications have been submitted to the NRC.[7] The data library also includes operator-provided information on the quantities of all SNF discharged by those reactors and held in either wet or dry storage through the end of 2009.[8] The quantities of fuel that will be discharged from the start of 2010 through the end of their operating lifetimes are projected by NUWASTE on the basis of the plant design and operating assumptions that are used to define a particular scenario.

6. Source: NRC Information Digest, NUREG-1350, Appendix A.
7. Source: EIA Web site, Status of Potential New Commercial Nuclear Reactors in the United States, www.eia.doe.gov/cneaf/nuclear/page/nuc_reactors/reactorcom.html.
8. Source: DOE TSM, TSMPP_SNF_Discharge_09_052809.xls.

On the basis of the assumed fuel burn-ups and initial enrichments, NUWASTE calculates the masses of individual isotopes in the spent-fuel assemblies that have been, or will be, discharged by the operating and currently planned fleet of nuclear power plants. The individual isotopes tracked by NUWASTE make up over 99 percent of the total fuel-assembly mass, including the major uranium and plutonium isotopes along with another 54 isotopes of fission-product elements and minor actinides.

The calculations of isotope masses in the SNF are made using the ORIGEN[9] computer code. On the basis of these calculations, NUWASTE can project the mass of each isotope that will be disposed of directly or separated during reprocessing for any given scenario. In the reprocessing scenarios evaluated for this report, NUWASTE does not reflect any particular separation technology.

The uranium and plutonium in a fuel assembly are considered to be separated completely into product streams, with the fission products and minor actinides separated into a high-level radioactive stream and a fission product gases waste stream. These streams are shown in Figure 1, together with other waste streams that are generated during reprocessing operations.

However, NUWASTE also has the flexibility to evaluate the more realistic case where complete separation cannot be achieved (e.g., the plutonium product stream contains some small percentage of uranium). This flexibility allows NUWASTE to project the effects of using the processes available today and some of the more advanced separation technologies being considered for potential application in the future. In some of these cases, incomplete separation of the uranium and plutonium maybe intended,

9. ORIGEN/SCALE 6.0 (Oak Ridge Isotope GENeration/ Standardized Computer Analyses for Licensing Evaluation) is a computer code developed at Oak Ridge National Laboratory to calculate the inventories of fission products and minor actinide elements in SNF discharged after irradiation in a reactor.

possibly with some of the fission-product or minor actinide materials also included in the combined product stream, to meet nonproliferation objectives.

On the basis of the quantities of materials in each product stream, NUWASTE then calculates the quantities of recycled fuel that can be fabricated for loading into reactors each year. It also calculates the volumes of HLW and other wastes that would be generated each year, adding them to the inventories requiring disposal. In each year, the maximum number of disposal waste packages containing SNF and HLW to be emplaced in a repository is projected.

Results

Using NUWASTE to assess the four scenarios considered in this report produced several notable insights.

Requirement for Dry-Storage Casks

Figure 2 shows the number of dry-storage casks required in each scenario. Absent a repository or a recycling program (Scenario 1), a total of more than 12,000 dry-storage casks will be required by the year 2100, each holding on average either 32 pressurized-water reactor (PWR) fuel assemblies or 68 boiling-water reactor (BWR) fuel assemblies.[10] The availability of a repository having a disposal capacity of 3,000 MT/year (Scenario 2), possibly combined with a reprocessing facility with a capacity of 1,500 MT/year (Scenarios 3 and 4), could significantly reduce the total number of dry-storage casks required, the size of the reduction depending on the facility receipt rates and start

10. Dry-storage casks with capacities of 32 PWR and 68 BWR are assumed for the purpose of these calculations and are representative of storage systems that currently are used by many utilities.

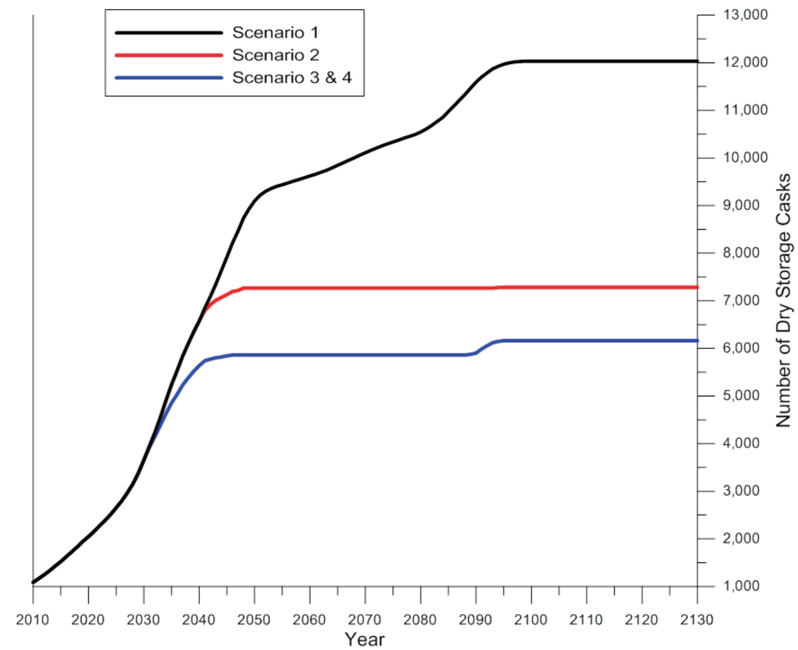

Figure 2. Number of Dry-Storage Casks Required

dates. However, as can be seen in Figure 2, even under the optimistic conditions assumed in Scenarios 3 and 4, more than 6,000 dry-storage casks still would be required.

Demand for Repository Disposal Waste Packages

Figure 3 shows the number of repository disposal waste packages[11] required in each scenario and the timeline over which they accumulate. Because there is no repository in Scenario 1, no disposal packages are required. Comparison of the results for the other scenarios allows the following observations to be made:

11. A repository disposal waste package may contain either SNF or HLW and is designed for emplacement in a repository for final disposal.

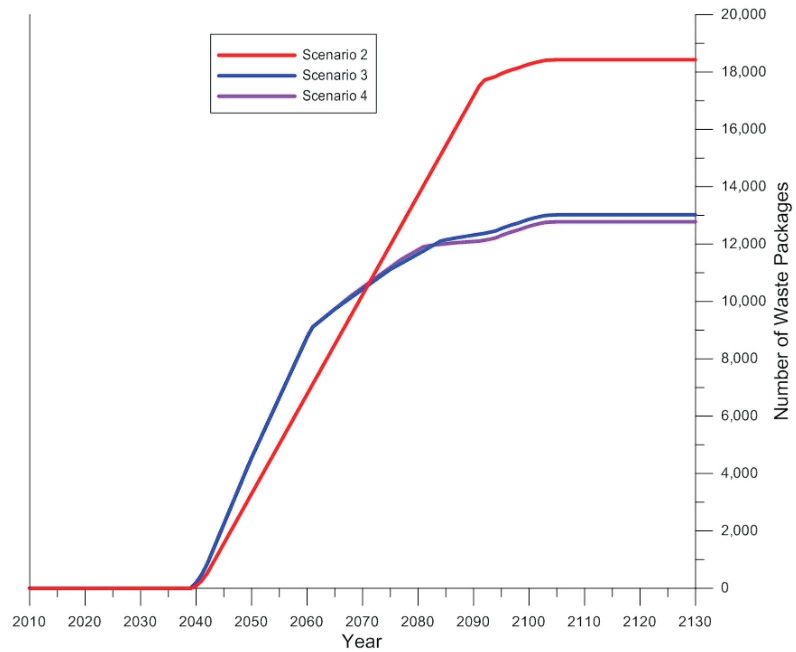

Figure 3. Number of Disposal Waste Packages Required

- Addition of a 1,500 MT/year reprocessing facility in Scenarios 3 and 4 to the repository included in Scenario 2 reduces the number of disposal waste packages required by approximately 30 percent.
- Despite this reduction, reprocessing does not remove the need for a repository.
- If reprocessing operations start before repository operations (as assumed in Scenarios 3 and 4), HLW canisters from reprocessing will start to accumulate before the repository can receive them for disposal, and storage capacity will need to be provided.

Demand for Natural Uranium

Another aspect of introducing reprocessing and recycling that can be analyzed using NUWASTE is the extent to which the demand for natural uranium would be reduced. Figure 4 shows that when both reprocessed uranium and plutonium are recycled once, as in Scenario 3, the effect is roughly a 14 percent reduction in the amount of natural uranium required when compared with Scenarios 1 and 2.[12] However, fuel assemblies with burn-ups of greater than approximately 55 GWd/MT have ^{236}U concentrations[13] that would require the reprocessed uranium to be enriched above

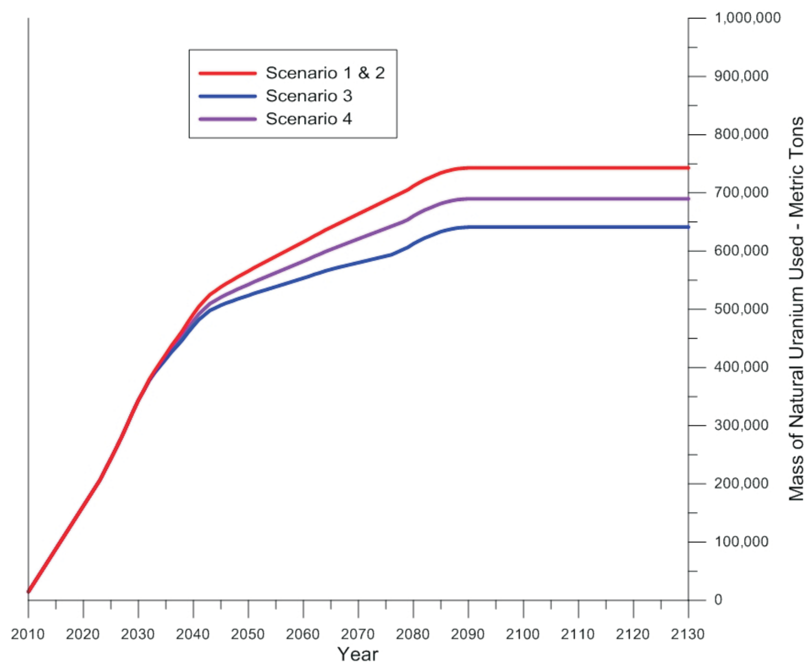

Figure 4. Natural Uranium Requirement

12. This reduction in uranium requirement results from the introduction of a reprocessing capacity of 1,500 MT/year in 2030. Increasing the reprocessing capacity potentially would result in an additional reduction in uranium requirement. However, there are practical limits on the extent to which uranium and plutonium can be recycled, and this will be the subject of further analysis using NUWASTE.

13. ^{236}U is an isotope of uranium produced during reactor operation. As it is a neutron absorber, uranium containing ^{236}U needs to be enriched to a higher ^{235}U content than fresh uranium if it is to be recycled into new fuel.

5.0 percent ^{235}U, which is the present license limit, and therefore would make the reprocessed uranium unsuitable for recycling in LWRs. This would reduce the uranium savings to approximately 7 percent (Scenario 4).

Waste Streams

The choice of fuel-cycle strategy also affects the volumes and types of wastes that would be generated in addition to HLW. Figure 5 shows the large quantity of low-level waste (LLW) and Greater-Than-Class-C (GTCC) waste that would be generated by reprocessing and repository operations.[14] Scenario 1 does not include a repository or a reprocessing facility, so no LLW or GTCC waste is generated by these activities. In the other scenarios,

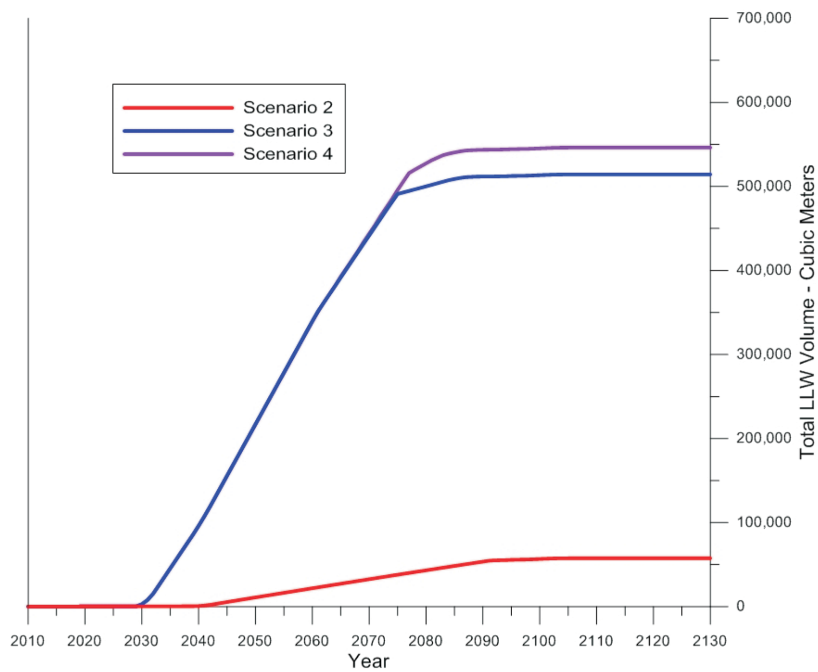

Figure 5. Quantity of LLW and GTCC Waste Generated

14. Source: Report FCRD-USED-2010-000033 Rev.0 "Low Level Waste Disposal – Quantities and Inventory," Savannah River Site report for DOE, June 2010.

a significant quantity of LLW is generated during facility operations, the quantity generated during reprocessing (Scenarios 3 and 4) being far greater than that generated during direct disposal of SNF (Scenario 2).

If the SNF received at a repository site or a reprocessing facility needs to be unloaded from the canisters in which it is contained for dry storage, additional quantities of LLW may be generated from the disposal of these dry-storage canisters. However, not all dry-storage systems use canisters, and some canisters may be able to be used as inner containers in the disposal waste packages. Consequently, there currently is no basis for projecting the magnitude of the additional LLW stream that would result from the disposal of dry-storage canisters, and it is not included in this analysis.

A breakdown of these waste streams is as follows:

Scenario 2: Repository Only

- LLW – 56,000 m^3

Scenario 3: Repository, Reprocessing, Recycling of Plutonium and Uranium

From Reprocessing Operations

- LLW – 441,000 m^3
- Mixed LLW[15] – 2,000 m^3
- GTCC waste – 12,000 m^3
- Mixed GTCC waste – 7,000 m^3

From Repository Operations

- LLW – 48,000 m^3

15. Mixed LLW and Mixed GTCC waste mean LLW and GTCC waste, respectively, that has chemical contents outside the usual specification for these wastes and may require additional packaging or disposal in accordance with the terms of the Resource Conservation and Recovery Act.

Scenario 4: Repository, Reprocessing, Recycling of Plutonium

From Reprocessing Operations

- LLW – 464,000 m^3
- Mixed LLW – 2,000 m^3
- GTCC waste – 13,000 m^3
- Mixed GTCC waste – 7,000 m^3

From Repository Operations

- LLW – 58,000 m^3

From these figures, it is apparent that LLW represents by far the largest component (more than 95 percent) of these waste streams that would be generated by reprocessing. However, it is important to note that it may be necessary to develop a below-surface disposal facility for GTCC waste. This would likely take longer, and be a more complex undertaking, than developing the additional disposal capacity required for the LLW.

Other Considerations

Other consequences of different fuel-cycle options also can be evaluated using NUWASTE. For example, NUWASTE projects the quantity of plutonium that would be separated during reprocessing.

Figure 6 shows how much plutonium would be separated on a cumulative basis by adopting either Scenario 3 or Scenario 4. From Figure 6, it is apparent that unless the fabrication and use of MOX fuel are managed successfully, a large plutonium stockpile would be created, potentially giving rise to proliferation concerns.

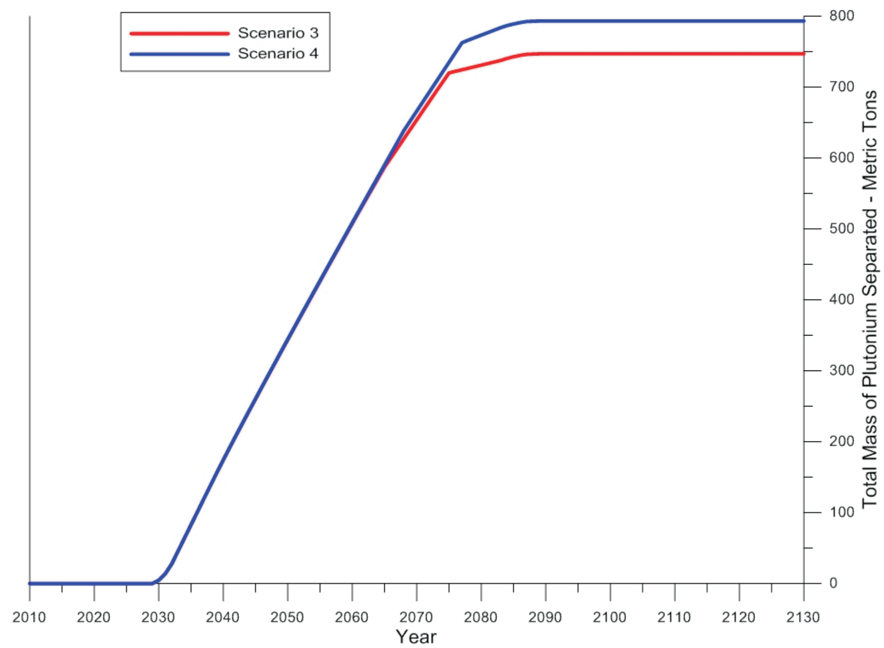

Figure 6. Quantity of Plutonium Separated by Reprocessing

Ongoing Activities

The Board is in the process of extending this analysis and increasing the scope and functionality of NUWASTE. Near-term plans include evaluating additional LWR scenarios and adding the capability to evaluate the relative effects of different fuel-cycle options on program costs and the operational timelines for the SNF management and waste disposal facilities required. Longer-term plans include expanding NUWASTE capability to:

- Analyze the waste-related effects of introducing advanced thermal reactors (Gen III and Gen IV types) and fast reactors.
- Evaluate the effect of adopting alternative reprocessing technologies.
- Include the disposal of all DOE-owned SNF and HLW.

- Project the capacities of away-from-reactor storage facilities that would be required for a range of centralized-storage scenarios.
- Estimate the transportation requirements at each stage of the fuel cycle.

As these developments are implemented, the Board will continue to report the results of its analyses to inform Congress, DOE, and other interested parties.

Glossary

Actinides. Elements with atomic numbers of 89 to 103. All actinides are radioactive, and all of the actinides in SNF are produced during reactor operation, with the sole exception of uranium and plutonium remaining from when the fuel was fabricated.

BWR. Boiling-water reactor.

Enrichment. Natural uranium contains approximately 0.7 percent of the isotope ^{235}U. For use in the fabrication of LWR fuel, uranium must contain, typically, between 3 percent and 5 percent ^{235}U. The process used to increase the percentage of ^{235}U is called "enrichment."

Fission products. Isotopes that result from the fission (splitting) of atoms of heavy elements, such as uranium and plutonium: for example, iodine-131 (^{131}I) and strontium-90 (^{90}Sr).

Fuel burn-up. See GWd/MT

GTCC waste. Greater-Than-Class-C (GTCC) waste is similar in origin, and in the types of materials it contains, to LLW. However, the concentrations of radionuclides in GTCC waste make it generally unacceptable for near-surface disposal. Consequently, GTCC waste may require disposal in an underground facility and could be co-disposed of in a deep geologic repository with HLW.

GWd/MT. Gigawatt days per metric ton (of fuel): a measure of the energy that has been produced by fuel (also referred to as the "burn-up" of the fuel) during reactor operation.

HLW. High-level radioactive waste: the primary waste stream from reprocessing – including, fission products and minor actinides, that can be vitrified into a solid glass waste form in high-integrity canisters that are suitable for repository disposal.

Light water. Water found in nature is essentially all "light water." Light water comprises two atoms of hydrogen and one atom of oxygen and has the molecular symbol "H_2O." Deuterium is a heavy isotope of hydrogen but is chemically similar to hydrogen. Thus, water also can comprise two deuterium atoms and one oxygen atom. In this form, it has the molecular symbol D_2O. Because deuterium is heavier than hydrogen, D_2O is referred to as "heavy water," which is required for the operation of some nuclear power plants. Consequently, LWRs are so called to make the distinction between them and reactors that require heavy water.

LLW. Low-level waste: materials with various physical and chemical characteristics and a range of concentrations of radioactive isotopes. It typically comprises mainly items such as coveralls, reactor water treatment residues, tools, and equipment, that have become contaminated with radioactive materials or have become radioactive through exposure to neutron radiation. The U.S. Nuclear Regulatory Commission classifies LLW in Classes A, B, and C, according to the concentrations of specific radionuclides, which are all suitable for disposal in near-surface disposal facilities.

LWR. Light-water reactor: BWRs and PWRs are light-water reactors. All nuclear power plants currently operating in the United States are LWRs.

Material balance. A method of accounting for nuclear materials as they move through the fuel-cycle operations in a scenario, in order to ensure that all material is recorded. This is similar to periodically balancing a bank account during a series of financial transactions.

MOX fuel. "Mixed oxide" fuel: fuel fabricated using a blend of plutonium oxide from SNF separated by reprocessing and uranium oxide. MOX fuel can be made using natural uranium, tails from enrichment, or uranium separated from SNF by reprocessing.

MT/yr. Metric tons per year.

PWR. Pressurized-water reactor.

Recycled tails. The tails resulting from enriching reprocessed uranium during recycling.

Recycling. Production of MOX fuel using plutonium from SNF separated by reprocessing and/or production of uranium fuel using re-enriched uranium separated from SNF by reprocessing.

Reprocessing. A process involving dissolution of SNF and chemical separation of the dissolved contents of the fuel into a uranium product stream, a plutonium product stream, a high-level radioactive waste stream, and a fission product gases waste stream. The uranium and plutonium products can be used for fabricating new fuel.

SNF. Spent nuclear fuel: Nuclear fuel that has been used in a reactor to generate power. Following discharge from a reactor, spent nuclear fuel may be reprocessed or disposed of directly in a repository.

Tails. The objective of enrichment is to produce uranium with an increased ^{235}U content than in natural uranium. The by-product of enrichment is a uranium waste stream with a reduced, or "depleted," ^{235}U content. This material is referred to as "tails."

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