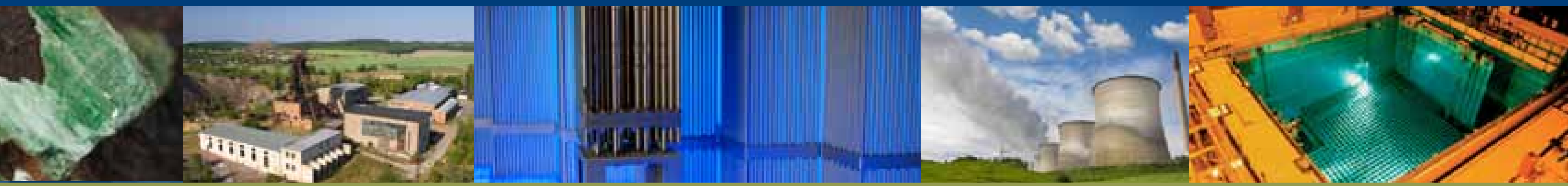
A Screening Method for Guiding R&D Decisions:

Pilot Application to Nuclear Fuel Cycle Options



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Introduction

The Department of Energy's Office of Nuclear Energy (DOE-NE) invests in research and development (R&D) to ensure that the United States will maintain its domestic nuclear energy capability and scientific and technical leadership in the international community of nuclear power nations in the years ahead. The 2010 *Nuclear Energy Research and Development Roadmap* presents a high-level vision and framework for R&D activities that are needed to keep the nuclear energy option viable in the near term and to expand its use in the decades ahead. The roadmap identifies the development of sustainable nuclear fuel cycles as a major R&D objective.

To achieve this objective, DOE-NE supports R&D to identify and resolve technical challenges related to sustainable nuclear fuel cycles. DOE-NE is selective about the technologies that it supports and seeks to direct its research funding to produce the maximum benefit. A principal challenge for DOE-NE in making these funding decisions is the high degree of uncertainty and complexity involved in anticipating the future potential of alternative technologies. Regarding the development of sustainable fuel cycles, this challenge is compounded by the wide range of technologies that DOE-NE must evaluate in order to make the best decisions. DOE-NE and other DOE programs can use a variety of decision-making methods to provide usable sets of R&D priorities. However, it is not enough simply to get the right outcome or answer at the end of the decision-making process. As DOE is a federal agency and steward of public trust, its decisions will be open to scrutiny. Therefore, *how* DOE programs obtain that answer is also important.

Sustainable Fuel Cycles

One of the key objectives stated in the 2010 *Nuclear Energy Research and Development Roadmap* is to "develop sustainable nuclear fuel cycles," where a "fuel cycle" is the progression of nuclear fuel from mining to power generation to ultimate disposal of the used fuel or derived waste products. As defined in the *Research Objective 3 Implementation Plan*, "sustainable" fuel cycle options are "those that improve uranium resource availability and utilization, minimize waste generation, and provide adequate capability and capacity to manage all wastes produced by the fuel cycle."

Serving Public Trust

DOE not only seeks to identify value-adding investment priorities, but also strives to do so in a way that instills public confidence. In the specific case of developing sustainable nuclear fuel cycles, DOE-NE's decisions about long-term R&D investments draw on a systematic evaluation of alternatives that both supports the achievement of program objectives and adheres to values that serve the public trust, such as accountability to stakeholders, due diligence, transparency, and stewardship.

Screening is choosing between different alternatives based on how well their attributes fulfill the program objectives.

A ***screening method*** is a way to identify options with a high potential to meet one or more program objectives in order to inform DOE-NE's investment decisions.

Approach: Piloting a New Method

As part of its effort to continually improve its decision making, DOE-NE developed and tested a method that will be applied to screening fuel cycle options. The method incorporates a comprehensive and systematic assessment of potential fuel cycle system options against criteria that reflect program objectives and societal needs. The intent was to develop a screening method that would offer valuable input to decision makers while also giving them a clear understanding of how the results were obtained.

To determine whether the method was viable and adds value, an initial, or pilot, screening was completed. The pilot served to accomplish the following:

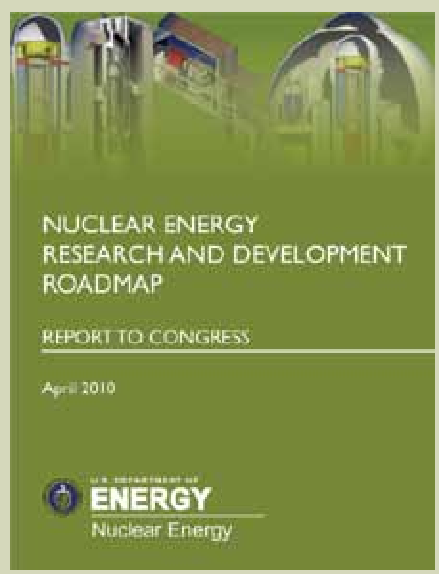
- Demonstrate a structured process to support future screenings and down-selections
- Identify improvements to the method that are needed before it is applied in a formal screening to be conducted in 2013
- Identify fuel cycle options that offer limited performance potential over the current fuel cycle and may be considered as not worthwhile to pursue for long-term R&D investment
- Provide a traceable and defensible basis for explaining investment decisions to stakeholders
- Highlight the critical importance of having policy makers explicitly identify the relative importance of the criteria upon which fuel cycle options are to be judged

The North Anna power station in Louisa County, VA.

The initial screening used a systematic approach for evaluating fuel cycle options. It included fuel cycle technologies and systems that have been considered both in the past and more recently. As the screening method is implemented during future screening activities, modifications to the process, criteria, and metrics will likely occur to reflect lessons learned.

To help our nation achieve its clean energy and energy security goals, DOE-NE enables the development and deployment of fission power systems for the production of electricity and process heat. The 2010 *Nuclear Energy Research and Development Roadmap* identifies the following four R&D objectives to guide NE's program and strategic planning:

- **Objective 1**: Sustain current reactors
- **Objective 2**: Improve affordability of new reactors
- **Objective 3**: Develop sustainable fuel cycles
- **Objective 4**: Reduce proliferation risk



To meet Objective 3 (develop sustainable fuel cycles), DOE-NE will research and develop nuclear fuel and waste management technologies within the following three fuel cycle strategies:

- *Once-through*, which removes and disposes of used reactor fuel after it has made a single pass through a reactor
- *Modified open cycle*, which applies limited separations and fuel processing technologies to used fuel to create new fuels
- *Full recycle*, which uses thermal- or fast-spectrum systems and reprocessing of used fuel to enable reuse of fuel resources and to minimize long-lived radiotoxic waste streams

Guiding Principles

The rationale for the screening method is summarized in the following set of principles, which clarify how DOE-NE understands "success" in both making choices in the face of uncertainty and making them via a defensible process. Some of these principles embody the systems engineering approach that contributed to the process, while others are unrelated to systems engineering. DOE-NE intended for the screening method to have the following attributes:

- **Requirements-based:** Screening criteria and metrics are established that align with DOE-NE objectives outlined in the 2010 *Nuclear Energy Research and Development Roadmap*. Stakeholder input is included in the development of criteria and metrics. The process focuses on fulfilling customer needs, including the most critical technical and programmatic challenges and the requirements defined by high-level DOE goals. These requirements guide the choice of metrics.

- **Technically rigorous:** The method incorporates the best available data and technical information. Although experts make the evaluations, the process can be repeated such that a different set of experts, using the same assumptions and interpretation of the criteria and having access to the same analysis, data, and information, should come to the same conclusion.

- **Inclusive:** The screening is approached with the goal of being inclusive and considering the maximum breadth of options regardless of technical maturity or current viability. Metrics for all key considerations, such as resource and waste attributes, are included.

- **Transparent:** The method is well documented and produces traceable documentation that is retrievable and can be reexamined. Conclusions are stated in a way that minimizes misinterpretation. The method does not appear more precise than it actually is; uncertainties are made visible in the results. The method by which results are obtained can be made meaningful to a broad range of audiences. The process can be presented with clarity to both technical and nontechnical stakeholders.

- **Reusable:** The method is consistent, systematic, and repeatable. Even in future years and under a different policy environment, the method remains usable because of the ability to attach different weights to criteria depending on different policy scenarios. The application of various weighting factors and go/no-go criteria provides an opportunity to examine the implication of diverse policy positions.

- **Self-evaluative:** The method evolves over time. Due diligence is demonstrated during its creation by verifying the results and the larger framework of the process itself through multiple stages of external review.

Members of the Initial Screening Evaluation Panel (ISEP) contributed their time and expertise to the process.

Electronic records captured the results from the ISEP's analysis.

DOE is striving to fully incorporate these principles into the formal screening planned for 2013. Results of the pilot give confidence that DOE-NE, by considering these guiding principles, will derive valid formal screening results through a process that itself supports DOE's mission to operate as a transparent, accountable public institution making decisions in the face of uncertainty.

The Method

A systematic process to evaluate fuel cycle options for their potential to meet program objectives enables the Fuel Cycle Technologies (FCT) Program to prioritize the associated R&D. The process may even be applicable to other aspects of nuclear power production or to other DOE programs. Toward these ends, the method was applied in an initial screening assessment that aimed not only to differentiate between less promising and more promising options, but also to do so in a defensible manner that corresponds to guiding principles.

This section describes the basic features of the method. It describes the general steps, explains their specific application in the pilot study, and shows how the specific application in the pilot demonstration serves to illustrate the generic process.

Introduction to the Method

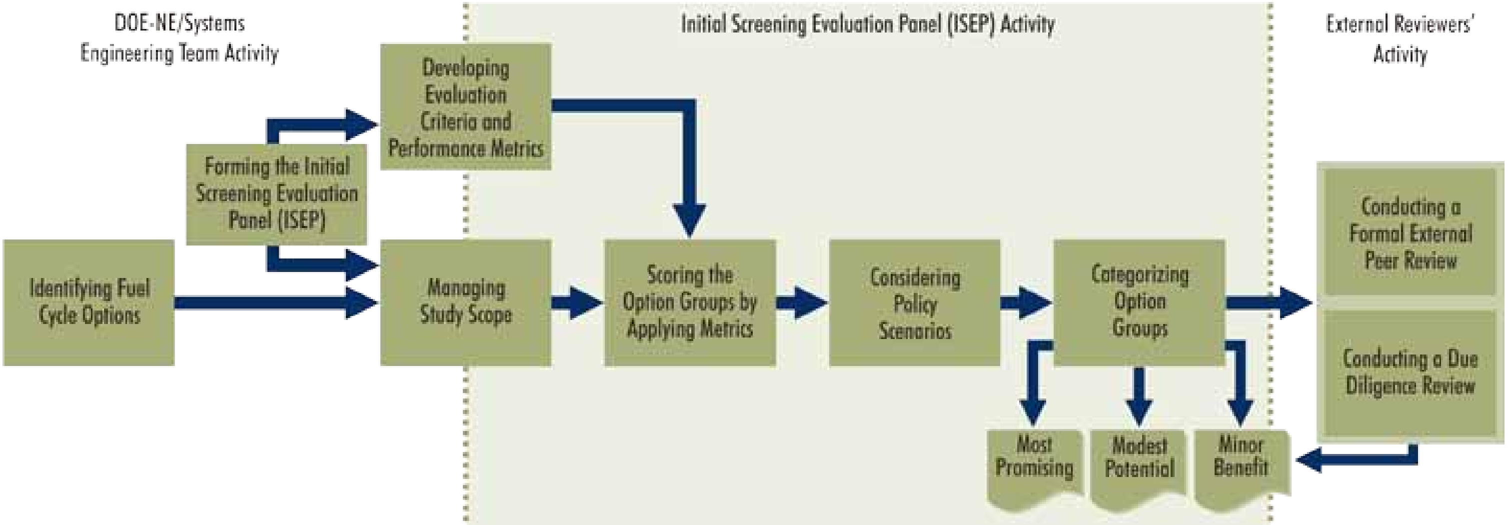
The method comprises a series of generic steps, designed according to the guiding principles previously described, that form a repeatable screening process:

- Developing evaluation criteria and performance metrics
- Forming an expert panel
- Identifying fuel cycle options
- Managing study scope
- Scoring the option groups by applying metrics
- Considering policy scenarios
- Categorizing option groups
- Conducting a formal external peer review

The first four steps—developing criteria and metrics, forming an expert panel, identifying options, and managing scope—may be performed in parallel, and precede the last four steps—applying metrics, considering scenarios, categorizing option groups, and conducting a formal review of the entire process.

Screening criteria included the fuel resource requirements and the environmental impacts of extracting uranium ore minerals such as these.

Pilot Study Process



This method enhances and validates the decision-making processes that are currently in place, serving as an additional tool that decision makers and policy makers can use to both make decisions and communicate the basis for those decisions. It provides a systematic way to ensure that decision making abides by the values of accountability, due diligence, transparency, and stewardship. The method documents how results were obtained and allows decision makers to better understand the reasons for the conclusions.

Introduction to the Pilot Study

In 2010, DOE-NE applied this method to initially screen nuclear fuel cycles. This application of the method is referred to as the "pilot study" or the initial screening. This pilot was a trial of the method, and was not intended as the formal screening of all fuel cycle options. It was designed to screen out options for long-term R&D with lower performance, assess the viability of the method, and identify improvements for the formal screening, which is slated for 2013. The experience of the initial screening project serves to exemplify and illustrate how the generic process may be applied.

Preparatory workshops increased the appropriateness of the criteria and metrics used.

Pilot Study Steps

The following sections trace the main steps followed in the pilot study and explain how they relate to the generic steps of the repeatable method.

Developing Evaluation Criteria and Performance Metrics

High-level criteria for fuel cycle performance must reflect the DOE program objective of developing sustainable end-state fuel cycles for the long term. The program's objective must be balanced with other societal needs, such that a sustainable fuel cycle is also economic, safe, and secure; minimizes environmental impact; and reduces proliferation risk.

Because high-level criteria, such as nuclear waste management, are difficult to quantify, particularly when applied directly to a specific fuel cycle option, each criterion must be decomposed into a set of more specific metrics or measures (e.g., mass of actinides sent to disposal) that can be used to rate the relative ability of each fuel cycle option to meet the high-level criteria.

In the pilot study, DOE-NE's Systems Engineering Team drew from past studies to develop a strawman set of proposed evaluation criteria and metrics. Next, the Evaluation Criteria and Performance Metrics Workshop, held on August 24–26, 2010, served to refine the proposed criteria and metrics with input from fuel cycle technology scientists, industry experts, and policy makers. At the workshop, the participating experts reached consensus on an initial set of evaluation criteria as well as the specific metrics for each criterion.

Forming an Expert Panel

No decision-making process can guarantee complete accuracy or ideal results in the face of an uncertain future. However, the likelihood of successfully incorporating existing knowledge and predicting future outcomes can be maximized by drawing on the best expertise available. A key element of the screening process is input and guidance from program participants, including technical subject matter experts from within DOE, industry, and academia. Their expertise may be included by forming an evaluation panel composed of subject matter experts.

For the pilot study's initial screening, DOE-NE formed the Initial Screening Evaluation Panel (ISEP)—a group of subject matter experts versed in the overall performance of nuclear fuel cycles and their associated technologies. These experts were either involved in or familiar with key prior studies. The ISEP was chosen to have a wide range of expert knowledge that covered nearly all major aspects of nuclear energy and the nuclear fuel cycle.

Identifying Fuel Cycle Options

In any decision-making process, existing recommendations and options cataloging efforts are likely to have preceded the current prioritization effort. In the case of nuclear fuel cycles, previous domestic and international studies have assessed the promise of fuel cycle options. A well-designed assessment method would take these studies into account as input to the process.

In the pilot study, the DOE-NE Systems Engineering Team undertook an option cataloging effort to develop a comprehensive set of several hundred fuel cycle options, including current, evolutionary, and revolutionary nuclear technologies. The Options Identification Workshop, held on August 2–4, 2010, served to identify the set of options in the FCT Options Catalog that perform specified functions. The team ensured that the list covered the full range of potentially feasible technologies and produced many recommendations to modify and

High-Level Evaluation Criteria

Performance:

- Nuclear waste management
- Resources
- Proliferation risk
- Safety
- Security
- Economics
- Environmental impact

Challenge:

- Technical maturity
- Licensability
- Institutional issues

Typical Nuclear Fuel Cycle

expand the list to meet this goal, while maintaining a comprehensive set of hundreds of fuel cycle options that would include all components of the fuel cycle. Existing work, such as a 2008 study of fuel cycles and technologies and a 2009 study of fuel cycle systems, served as resources and inputs to the process.

Managing Study Scope

The challenge of making R&D investment decisions is frequently compounded by the number of potential technologies from which to choose, as well as the uncertainty in trying to predict the long-term potential of these choices. Given that screening hundreds of options (i.e., hundreds of combinations of technologies) and their myriad variations would be expensive and inefficient, there is much value in creating an options set that is both reduced and representative. A clear need exists to produce a representative set of fuel cycle options that captures the major features and technologies of the complete set.

In the pilot study, decisions were made to limit the scope of the initial screening. Using option groups and limiting the parts of the fuel cycle being examined helped to manage the pilot study's scope.

- **Using option groups**: A comprehensive set of more than 800 fuel cycle system options was considered as input to the pilot screening study. Evaluating this many options would have been impossible to accomplish within the given time constraints. Therefore, the comprehensive set of fuel cycle options was reduced to a set of 258 option groups that represented the broad range of fuel cycle technologies. These 258 option groups were organized by functional similarity into a smaller set of 55 option groups for scoring in this initial screening. The ISEP then identified a representative system option, selected from those in each option group as the member of that group that was likely to score the highest among those options represented in the set. By rating the representative option of each group, the ISEP was able to be inclusive while keeping the evaluation task manageable and efficient.

- **Limiting the portion of the fuel cycle being examined:** In order to manage the study's scope, only technologies in the middle part of the fuel cycle were considered while defining options. As a result, specific technologies for functions of the fuel cycle upstream of fuel use (the front-end of the fuel cycle, including resource extraction and conversion) and downstream of waste stream generation (the back-end of the fuel

Use of option groups enabled an inclusive screening.

cycle, including waste forms, storage, transportation, and site-specific system disposal design) were not directly evaluated. This does not mean that impacts of these upstream and downstream functions were excluded. They were still parametrically represented by performance metrics that considered proliferation risks, waste quantities, environmental impacts from mining and ore extraction, and the waste's decay heat and radiotoxicity long after discharge. Limiting the portion of the fuel cycle for which specific representative technologies were considered was an expedient choice for the initial pilot of the assessment method, enabling time constraints to be met.

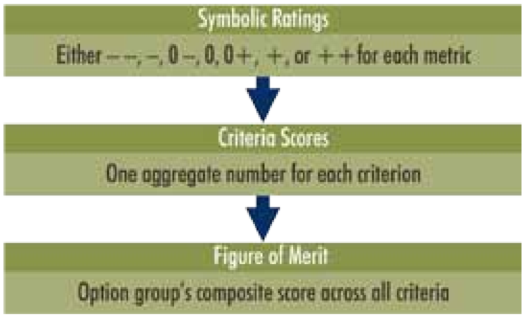
Scoring the Option Groups by Applying Metrics

In applying metrics to evaluate options, it is essential to avoid creating an appearance that the results are more precise or accurate than the evaluation method actually allows for, particularly when some degree of qualitative assessment is involved. The evaluation process calls for experts to assign quantitative values for each metric for each criterion. While the record of the individual metric scores enhances the traceability and transparency of the process, this rating is not the end of the process. These scores, along with the scenario analysis described below, are used to categorize the options into three categories: minor benefit, modest potential, and most promising. This categorization of options into broad categories, rather than a precise numerical rating for each metric, is the intended goal of the method. Accordingly, the precision and accuracy of the evaluation process should be judged relative to the final categorization, not the specific numerical scores.

In the pilot study, each option group was evaluated with respect to each criterion and metric on a qualitative scale relative to the current reference fuel cycle (i.e., the once-through use of uranium-based nuclear fuel in light water reactors). Technology readiness levels were assigned to each fuel cycle option group. Varying types of criteria (including go/no-go criteria and continuous criteria) were used, as well as varying types of metrics (both performance and challenge metrics). This categorization of the metrics enabled a two-dimensional analysis of fuel cycles, with one dimension being technical performance and the other being the challenge (technical, programmatic, etc.) of implementing the fuel cycle. The ISEP judged the representative option for each option group to be much worse than, worse than, slightly worse than, similar to, slightly better than, better than, or much better than the reference fuel cycle for each evaluated metric. These ratings, along with notes on the basis for the ratings, were recorded on scoring sheets that provide traceable documentation of the evaluation judgments. The metric ratings, designated symbolically as [– –, –, 0–, 0, 0+, +, ++], were converted

- **Continuous criteria** are criteria with a range of acceptable values.
- **Go/no-go criteria** are criteria with a designated threshold value; if the value is not met, then the option or technology is placed in the "no-go" minor-benefit category and recommended as not worthwhile to pursue.
- **Performance metrics** measure how well a fuel cycle option performs in comparison to the current reference fuel cycle.
- **Challenge metrics** measure the challenge of developing and deploying technologies that enable use of the fuel cycle option.
- **Weight** is the relative importance assigned to a metric or a criterion.

Transition from Symbolic Ratings to Figures of Merit



to numbers to create a numerical criterion score. For some metrics, these ratings corresponded to quantitative measures; and for others, these scores were qualitative comparisons to the reference case. The numerical criterion scores were compiled to create an overall figure of merit for the option group.

Considering Policy Scenarios

Rating criteria by themselves do not reflect policy priorities that must be considered when making R&D investment decisions. Rather, the policy context influences the definition of success. For example, giving a different weight to the importance of managing proliferation risk versus the weight given to resource utilization—or weighting them both equally—may affect the categorization of options. It is essential to investigate and display this dependence. Weighting the criteria differently can reflect different perceptions as to the relative importance of the various criteria and metrics. Each set of criteria weights can be referred to as a scenario. These scenarios are intended to represent specific perspectives on the relative importance of waste manageability, resource utilization, safety and environmental considerations, and proliferation and security risks.

Six scenarios, representing different possible priorities for the nation's nuclear energy future, were considered in the pilot study based on a set of criteria and weights described below:

- **Equal weighting:** The viewpoint that all high-level criteria (i.e., nuclear waste management, resources, safety and environmental impact, and proliferation risk and security) are equally important in fuel cycle selection
- **Safety and environmental impact:** The viewpoint that fuel cycle safety and environmental protection are the overriding (although not the only) factors in fuel cycle selection
- **Waste attributes:** The viewpoint that a fuel cycle's ability to manage the disposition of wastes, including any used fuel, is the overriding factor in fuel cycle selection
- **Resources:** The viewpoint that the ability to better utilize uranium and/or thorium resources is the overriding factor in fuel cycle selection
- **Proliferation and security:** The viewpoint that proliferation risk and security risk are the overriding factors for fuel cycle selection
- **Unlimited resources:** The viewpoint that uranium and/or thorium resources are not a constraint on the nuclear fuel cycle for the foreseeable future

The Cameco Corporation Crow Butte uranium mine in northeast Nebraska.

Use of these example scenarios showed how an option's overall figure of merit score depended on criterion weights.

Categorizing Option Groups

The end goal of the screening method is to classify nuclear fuel cycle options into broad categories of potential performance. This "binning" is based on both the potential performance of the fuel cycles and the challenge (or cost and technical risk) in bringing them to deployment. The results of binning the fuel cycle options provide useful information to guide future R&D. This classification process is an expedient step toward extracting specific technology priorities.

In the pilot study, the fuel cycle option groups were classified into three broad categories: those that are most promising for achieving the sustainability objectives, those with modest potential for achieving sustainability objectives, and those that provide at best only minor benefit for achieving the sustainability objectives. The previous work of assigning metrics ratings, the calculation of criterion scores and overall figures of merit, and the scenario analyses were all used to inform this final evaluation step and help the ISEP arrive at a consensus on the binning of each option group.

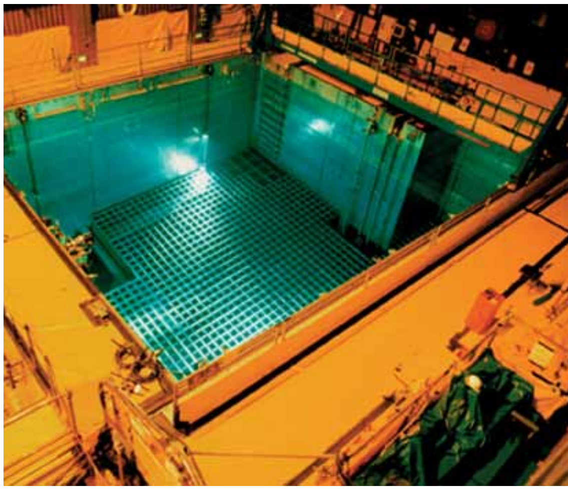
Conducting a Formal External Peer Review

For any evaluation, an external peer review serves to determine the reasonableness of the assumptions, appropriateness of the methods, and validity of the inputs. It demonstrates due diligence and increases the transparency of the process.

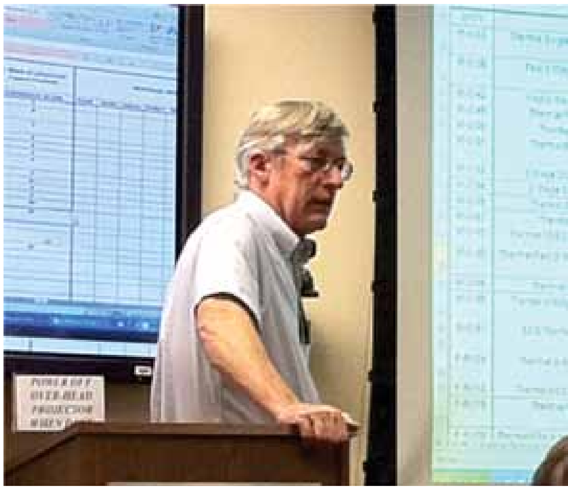
The pilot study incorporated two formal external reviews. First, an expert Peer Review Group assessed the initial screening process and its overall conclusions. The Peer Review Group found that "the construction of the screening (inputs, assumptions, and methods) and the screening conclusions were reasonable and useful for a pilot project." Second, the minor-benefit category was subjected to an additional, independent due diligence review to determine whether any of its options should be moved to the higher category of modest potential. The due diligence review was conducted by a separate group of program staff organized by the FCT Technical Integration Office and included representation from the technology R&D campaigns and program management.

Output of Pilot Screening

Although the pilot screening does provide some input to R&D prioritization, it has not declared any fuel cycle option the "winner." Declaring a winner was not the purpose of this initial application of the method. However, the method could be used for this purpose if it featured an enhanced set of fuel cycle metrics, additional analyses, further stakeholder input, and definitive



A **spent fuel pool** helps to store depleted fuel assemblies that have been removed from a reactor (*Source: nrc.gov*).



The ISEP's early screening decisions were captured via transparent, traceable, and reproducible documentation.

policy-driven weighting factors. The results of any such further screening, supplemented with additional system analyses, could be used to inform the prioritization of fuel cycle R&D activities.

The pilot screening has, however, yielded valuable information on both fuel cycle options and the ways that the pilot study (and generic method) succeeded or struggled. This section will consider the most concrete outputs of the pilot, including recommendations on R&D fuel cycle prioritization.

A flatbed truck transports decommissioned reactor parts.

- **Initial screening results were obtained.** The pilot study produced screening results for each of the option groups. These results give an initial indication of each option group's long-term potential and offer useful insights that are consistent with prior analyses, such as the 2009 options study of alternate nuclear fuel cycles. Although this initial screening should be considered as only a pilot application of the method, given limitations on both the metrics scored and the absence of specific front- and back-end technologies, the resulting high-level insights and conclusions regarding the characteristics of different fuel cycle option groups are consistent with results of previous studies and are likely to remain valid as the method is matured.
- **The ISEP concluded that approximately 20 percent of the option groups provide limited benefit toward the programmatic objectives and could be considered by the program to be "not worthwhile to pursue for long-term R&D for the development of sustainable fuel cycles."** The ISEP considers the fuel cycle option groups that have been initially placed in both the most-promising and modest-potential categories as candidates for future screening and for identification of specific technologies for R&D. In contrast, the screening process found the fuel cycle groups in the minor-benefit category to be not worthwhile to pursue for meeting long-term FCT Program's R&D goals. The fuel cycle option groups categorized as offering only minor benefit would likely not change even if a more comprehensive and inclusive analysis were performed with additional metrics and specific details on front- and back-end technologies. This conclusion is largely a result of the fact that the fuel cycle option groups in this category provided insignificant improvements in either resource utilization or waste stream characteristics relative to the current reference fuel cycle. Thus, any future evaluation of these fuel cycle options should be relatively insensitive to the inclusion of additional metrics and specific front- and back-end technologies. This conclusion was confirmed by the due diligence review discussed earlier.

The method incorporates the best available data and technical information.

- **A successful first test of a systematic assessment method was performed.** This initial pilot evaluation has demonstrated a systematic, traceable method based on systems engineering principles for categorizing nuclear fuel cycles according to their potential to meet FCT Program objectives. By connecting potential fuel cycle performance with high-level FCT Program objectives, the method supports the connection between the program's R&D activities and its strategic mission. After improvements judged as desirable are made in several parts of the method, conclusions drawn from future implementations of the method can be employed by DOE and DOE-NE management to inform and explain R&D portfolio investment strategies.

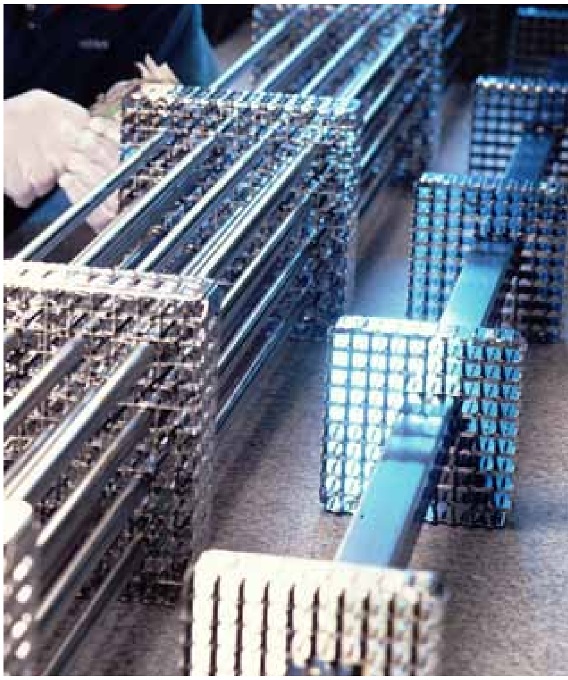
Key Insights

In addition to these outputs, the pilot study produced several key clarifications that may help inform future R&D related to the development of, and transition to, sustainable fuel cycle strategies.

- **It clarified the potential and role of the three strategies.** Three potential strategies have been envisioned for used fuel management: (1) once-through fuel cycles, (2) modified open fuel cycles, and (3) full recycle fuel cycles. Consistent with the findings of previous studies, full recycle fuel cycle options usually ranked highly according to the metrics and criteria weighting scenarios used in the pilot study. Once-through fuel cycle groups generally performed below the full recycle fuel cycle option groups. Few modified open fuel cycle options performed as well overall as the full recycle and once-through fuel cycle options. The ISEP observed that some of the modified open fuel cycle options may be better considered as examples of the transition from the currently operating light water reactors to a future equilibrium advanced fuel cycle.

- **It clarified the potential of thorium/uranium-233 (Th/^{233}U) fuel cycles.** The preliminary results of this pilot suggest that Th/^{233}U full recycle fuel cycles warrant further exploration as long-term fuel cycle options because they show significant potential as a sustainable fuel cycle relative to the current fuel cycle. However, the United States has conducted little R&D in the Th/^{233}U fuel cycle arena in the past three decades. The pilot study results indicate that the Th/^{233}U and the uranium/plutonium-239 (U/^{239}Pu) full recycle fuel cycles scored similarly.

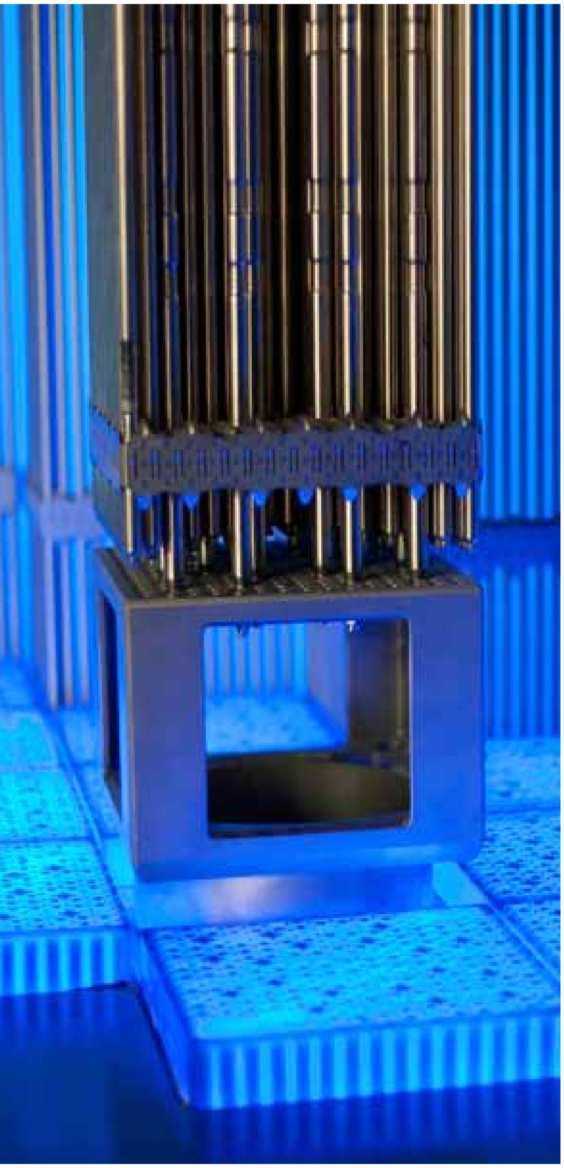
- **It clarified the need to examine transitions between fuel cycle options.** Future screenings should consider not only the end state in which a particular fuel cycle is well established, but also various paths for transitioning from the once-through, uranium-based, light-water reactor fuel cycle in current use in the United States to one or more preferred end-state fuel cycles. Because the pilot only examined future equilibrium



A technician fabricating a fuel assembly.

states of the fuel cycle, the evaluation of transitions from the current once-through cycle is not yet included. An opportunity exists to use the results of this initial pilot and subsequent screenings to derive transitional fuel cycle options for those equilibrium options that show the highest performance potential.

Strengths of the Screening Method



A fuel assembly inside a reactor core.

The pilot study demonstrated several fundamental strengths of the screening method, which reflect the guiding principles behind its design.

- **It provides a framework for strategic decision making.** The screening method proved able to help program management explain the connection between programmatic objectives and technology research, enabling resource allocation decisions to be made more systematically and comprehensively. It has also highlighted the critical importance of having policy makers explicitly identify the relative importance of the criteria upon which fuel cycle options must be judged.
- **It draws from stakeholder participation and existing knowledge.** The screening method included preparatory workshops involving experts and stakeholders that increased the appropriateness of the criteria and metrics used for screening. DOE-NE held one workshop to develop fuel cycle options and another workshop to develop criteria and metrics, both in August 2010. Participants included program managers, subject matter experts, policy experts, and representatives of industry.
- **It conducts evaluations efficiently.** The method's development of fuel cycle option groups and scoring of a representative fuel cycle option from each group appears to be a reasonable way to reduce almost certainly duplicative, time-consuming scoring to a more manageable level. This grouping method allows all fuel cycle strategies to be considered, including once-through, modified open, and full recycle options. It also provides a foundation for identifying crosscutting enabling technologies, defined as technologies that may support more than one of the most promising fuel cycle options.
- **It features a flexible, robust rating process.** The screening method's scoring framework proved able to account for a range of priorities. In particular, the ability to assess six scenarios representing differing weightings of the selection criteria allowed the ISEP to evaluate the relative sensitivity and importance of various criteria in the scoring process. By applying tests of internal consistency, such as rescoring some options and comparing those to earlier scoring, the process was able to address potential biases.

- **It achieves outputs with an appropriate level of specificity.** The screening method achieved the appropriate level of binning for this initial screening and perhaps for future screenings as well. The metrics scoring process, developed on a non-numerical scale, avoided overstating the precision of the method as applied during the pilot.

- **It encourages transparency and documentation.** The screening method encourages documentation of the decision-making process to enhance transparency, create insight, and allow education and communication to both technical and nontechnical audiences.

Going Forward

The pilot screening also was effective in suggesting pathways for refining the method's application to better support strategic decision making in a formal screening to be conducted in 2013. These refinements build on the demonstrated strengths of the method. Going forward, DOE-NE will broaden stakeholder participation and input, particularly in regard to the development and refinement of the criteria and metrics. In addition, the process and its results will provide a stimulus for dialogue among a variety of practitioner and stakeholder groups within the domestic, federal, and private sectors, and between the United States and other nations. The detailed documentation of how the results were obtained will also encourage others to examine the technical basis for their own viewpoints, while using a common basis for the discussion. The method may thus support communication and understanding across technical and non-technical stakeholder groups. Finally, the scenario analyses will help to inform and engage policy makers. The results will give decision makers an opportunity to see, in very concrete terms, the implications of diverse priorities and weighting of issues. This will enable DOE-NE to ask more specific questions and allow policy makers to effect a more definitive examination and articulation of policy positions.

A Final Word

The pilot study was very successful on several levels. It demonstrated the screening method's potential for assessing alternative fuel cycles against high-level criteria that reflect program objectives and societal needs. It showed that the method incorporates the best available technical knowledge and multiple external reviews to ensure valid results that support strategic decision making. It also showed that the method considers options in a systematic and rigorous way while adhering to values that demonstrate DOE's commitment to serving the public trust, including accountability, due diligence, transparency, and stewardship.

A **cooling tower** is a heat exchanger that cools water that was used to cool exhaust steam from a power plant's turbines (*Definition source: nrc.gov*).