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Emerging Prospects for Repository Success

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Recent events are again raising some old issues and creating new opportunities regarding the future disposition of the used, or spent, fuel from nuclear power plants. Handling these challenges well will not only help set the stage for a robust nuclear energy future, but will reflect the growing linkages among nuclear power, nuclear waste management, international security, and public and political acceptance. The emerging global nuclear regime may make spent fuel management not only more important, but improve chances of success.

Today's context

Today, some 441 nuclear reactors operating in over 30 countries supply approximately 16% of the world's electricity. They were built in less than 50 years, an impressively rapid introduction rate of a new technology when compared with the time it took for previous major energy contributors like coal and oil to achieve similar market penetration.

In many respects, however, nuclear power growth reached a plateau 10-15 years ago. More recently the introduction of new plants, the spread to new countries, and the development of key elements of the fuel cycle such as enrichment, reprocessing, and waste disposal have been quite modest. However, it seems that a renewed growth and spread of nuclear power plants and associated fuel cycle facilities and activities may begin soon, perhaps in the coming decade. The drivers are several: the certain growth of energy demand, particularly for electricity in the developing world; the increasing awareness of growing competition for energy sources and the concomitant enhanced desire for security in national energy supply; the increasingly obvious conclusion that burning of fossil fuels for energy is a major contributor to global warming and environmental degradation; the location of many of the world's largest oil and gas reserves in politically risky states; and the unpredictable and often rising costs of alternative energy sources such as oil and gas.

An expected resurgence of nuclear power carries with it the need to overcome a series of hurdles that have been well articulated in many places. The needs include assured financing for plants that are expensive and capital intensive, economic forecasts that demonstrate reasonable returns on investment, licensing regimes that provide confidence in timely processes and decisions, public acceptance in a world that still remembers Three Mile Island and Chernobyl, unquestioned continued quality performance and attention to safety, and the development of a nuclear regime that allows for the growth and spread of nuclear power while reducing prospects for nuclear proliferation and terrorism.

Not included in the above list is a key challenge: a demonstrated solution to the disposal of the high-level radioactive waste contained in the spent fuel. Whether the spent fuel elements are disposed of directly or the fuel is reprocessed to extract and reuse the

remaining uranium and produced plutonium, there is today no operating facility for permanent disposal. The wastes must be carefully and safely managed. Fortunately, the track record gives high confidence, as the U.S. Nuclear Regulatory Commission has stated, that spent fuel elements can be safely stored either in water pools or dry casks for decades. Yet the radioactivity remains a potential hazard for millennia, and it is generally agreed that one cannot count on institutional control to isolate the waste for the many thousands of years to come.

In 1957, a U.S. National Academy of Sciences report recommended that high-level radioactive wastes (HLW), such as those in spent reactor fuel, could be safely and permanently disposed of in deep, stable geological formations. They reasoned that since there are many places in the world where the geology has been stable for millions of years, finding and demonstrating a suitable location would be a preferred solution. Remarkably, almost 50 years later, this conclusion remains the anticipated ultimate solution for essentially every country that has a mature program. While other ideas have been generated and studied for decades, they have been found wanting. They are at a much too early, "romantic" stage to depend on; they require extensive, costly, and highly uncertain research programs; and even if successful they will not eliminate but only diminish the needs for an ultimate repository.

Yet developing and opening a geologic repository is difficult. Many countries with nuclear power programs have or had significant repository programs, but with a few exceptions (Finland and perhaps Sweden), they have had major setbacks in progress and schedule (e.g. U.S., France, Canada, Switzerland, Germany, Spain, and Great Britain).

The reasons for difficulties are many and varied, but two stand out. First, there is the scientific and technical challenge of demonstrating to a licensing authority and skeptical public that the natural and engineered barriers in the repository location deep underground can be relied upon to isolate the waste for the time period during which it is hazardous—many tens, perhaps hundreds of thousands of years.

Second is the political, institutional, and public challenge of siting; that is, achieving acceptance for any location as the site of a nation's nuclear waste final repository. High-level radioactive waste is a third rail of local, regional, and often national politics. Public reaction and opposition is often so intense that affected politicians have only two choices: oppose every effort to consider their jurisdictions or look for a new vocation. In general, these institutional challenges appear to be greatest in countries, like the U.S., with the equivalent of strong State government. While local communities near a candidate site may see benefits in job creation, technology, and compensation, sites are by their nature usually in remote locations. The population and political centers within a State are elsewhere and tend to focus much more on the perceived environmental consequences and societal stigma of being a repository, particularly when the wastes have been created elsewhere.

Prospects for Success

So how can we improve chances of successfully building a HLW repository that protects the public and earns their trust and confidence?

Let's begin by reviewing some of the key conclusions of one seminal document on the subject, "Rethinking High-Level Waste," prepared by a U.S. National Academy of Sciences committee in 1990, with extensive international participation. The study was prompted by continuing frustration and lack of sustained progress in the U.S. repository program, which by that time had been focused on one site alone: Yucca Mountain, a remote location 100 miles northwest of Las Vegas.

The Academy report concluded that the U.S. program at the time was unlikely to succeed largely because it did not take into consideration and accommodate the unique feature of this first-of-a-kind, highly controversial program. Schedules and budgets had been laid out as if we knew in advance everything that would be required, including the time and effort necessary to resolve the unknowns. The program was too inflexible and prescriptive. And when the inevitable technical and institutional surprises arose, the tendency was to grudgingly modify the program expectations with another highly optimistic and prescriptive program which once again had a rigid schedule and anticipated that we could design a "perfect" program in advance. It was often said that "there's never enough time to do it right, but always enough time to do it over."

One could say that the U.S. program has operated under an artificial and in some respects continual pressure, some of it self-inflicted. At many times over the past 20 years, it seemed as if the next few months were critical to program survival. The initial Nuclear Waste Policy Act of 1982 helped create this atmosphere by legislating specific and very aggressive early dates for decisions together with an unrealistic 1998 date for initial operation without much consideration of the scientific, technical, programmatic, or institutional challenges and requirements. The Act and contracts with the utilities stipulated the beginning of spent fuel acceptance by January 31, 1998, in return for a fee that the utilities pay to support the program. This exacerbated programmatic pressure. This date is now well in the past and the utilities have sued the government for not meeting their contractual obligations. Ironically, the continual pressure to not only open the repository, but fill it quickly, often resulted in short term decisions to meet self-imposed deadlines that resulted in further program delays. With a scheduled date of initial operation that has slipped more than 15 years in the past 20, naturally confidence in the program has suffered. Recent program decisions may finally be reflecting a growing appreciation of these circumstances.

The "Rethinking" report made a number of suggestions about how to reshape the program. Most important was the recommendation that the program adopt an flexible, incremental approach. The program should be defined broadly and based on a learn-as-you-go, improve-as-you-learn attitude. Such a program would not only be much better aligned with the unique technical challenges outlined before, it would provide opportunities to build stakeholder confidence. By involving stakeholders in decisions along the way, by responding to their concerns, and by delivering again and again on promises, one would have opportunities to earn trust. Building the program in stages—

with decision points to evaluate how best to proceed after each stage—would encourage optimization based upon experience. By building the actual repository in stages, for example with an initial pilot stage and a continuing research and development program, the implementer could demonstrate responsiveness, competence, and an ongoing commitment to continuous improvement. In Nevada, it's highly unlikely to affect the position of state-level elected politicians any time soon, but it may pay dividends among the broad public in the longer term.

This approach was further refined in a subsequent Academy report, "One Step at a Time", issued in 2003. It defined and described in detail, "Adaptive Staging." This approach can take full advantage of a repository's unique features:

 The repository is passive after completion; there are no moving parts;
 Occurrences are not likely for a long time and in most cases would occur slowly, if at all;
 If properly designed, there is no inherent energy to release materials;
 It only becomes a repository upon closure, at a time when future generations are confident and comfortable with that decision; and
 Until then, the process is reversible, and the waste is retrievable.

With its focus on the disposal of spent fuel soon and rapidly, the U.S. program has not succeeded. In contrast, an adaptive approach leads to the possible redefinition of program success by including as key elements:

 Identification of a suitable repository site, in the U.S., namely Yucca Mountain;
 A license from the regulator for permanent disposal of the complete intended inventory;
 The emplacement of an initial amount of waste to exercise operations and begin confirmatory work on system performance;
 Improvements in system design and operation in subsequent stages based upon experience and lessons learned;
 The option to emplace more waste;
 A place to store the remaining waste in the meantime;

The emphasis remains on the early establishment of the capability and demonstration of disposal, but allows for sequential decisions and pacing depending upon experiences in the initial stages and the unfolding of policy, programmatic, and societal requirements.

Canada's Recent Recommendation

Recently Canada has embraced a comparable approach as it begins to reconfigure its program to manage spent or used fuel. In 1998, a Canadian federal independent environment assessment panel finished its review of Canada's AECL proposal for deep geologic disposal. The Seaborn Panel, named after its chairman, made several fundamental conclusions in its final report, among them:

 “From a technical perspective, safety of the AECL concept has been on balance adequately demonstrated for a conceptual stage of development, but from a social perspective, it has not;

 “As it stands, the AECL concept for deep geologic disposal has not been demonstrated to have broad public support. The concept in its current form does not have the required level of acceptability to be adopted as Canada’s approach for managing nuclear fuel wastes.

 “Safety is a key part, but only one part, of acceptability. Safety must be viewed from two complementary perspectives: technical and social.”

Following the Seaborn Report, the Government passed the Nuclear Fuel Waste Act in 2002. The Act created the Nuclear Waste Management Organization (NWMO) and charged it to make recommendations within three years regarding the appropriate long-term management for Canada’s spent fuel. NWMO analyzed in detail several potential methods for long-term management and disposition. Evaluation of three approaches were specifically required: at-reactor storage, centralized storage, and deep geologic disposal. NWMO has effectively incorporated what it terms “Adaptive Phased Management” into its recent recommendation to the Canadian Government on how the nation’s spent nuclear fuel should be managed. As they state in the NWMO recommendation report, “Choosing a Way Forward”:

“…Canadians have expressed two complementary objectives. They are prepared to assume responsibility now for dealing with used fuel that has been created, but they also want to preserve the ability of future generations to do what they see as being in their best interests.

“…The challenge of taking the long view demanded by this issue caused us to explore how we could build in sequential decision-making which would preserve flexibility during implementation in the coming years.

“Adaptive Phased Management consists of both a technical method and a management system. The key attributes are:

 “Ultimate centralized containment and isolation of used nuclear fuel in an appropriate geological formation;

 Phased and adaptive decision-making;

 Optional shallow storage at the central site prior to placement in the repository;

 Continuous monitoring;

 Provision for retrievability; and

 Citizen engagement."

It will of great interest to see how the Canadian Government and affected parties respond to this recommended approach which resulted from a thorough analysis and an extensive and iterative engagement process. National reviews are also underway in Great Britain and France.

Doing the Right Thing Right

Recently, there has once again been discussion about slowing down or even halting the U.S. repository program. One can understand the frustration given the continuing difficulties and delays in preparing a suitable license application to the regulatory authority, the Nuclear Regulatory Commission; the continuing schedule slippages; large ongoing program costs; the intractable, if understandable, opposition from elected officials in the State of Nevada; and an environmental standard for licensing that is still not finalized.

Some are now suggesting that we move to a program of extended interim storage, either at reactor sites or perhaps in one or more centralized locations. We could then turn our attention to developing new nuclear reactor and fuel cycle facilities that, if successful, might allow for the reprocessing (separation) and reuse of the unused uranium and produced plutonium, leaving only the residue wastes for ultimate disposal. The idea of partitioning and transmutation might someday even allow for reactors or accelerators that would burn long-lived waste products and leave wastes that would only be hazardous for centuries rather than millennia. And perhaps it might delay the need for additional repositories.

Research and development on these new frontiers has much to recommend it. There are very large uncertainties and exciting scientific challenges to make such a system a reality. However, we are very far from confident that such work will result in a practical, effective, economic system. Even then it will take literally generations of remarkably stable, highly organized, and integrated programs to deal with all of the nation's spent fuel. Anything less would leave the waste situation unresolved and potentially more intractable. Even if successful, a repository would be needed for residual wastes.

It is also hard to imagine public acceptance based upon an unproven, highly sophisticated, and very costly program that would last decades before it has a significant impact. How would the nuclear community make a convincing case for a resurgence of nuclear power if its actions communicate an inability to solve the disposition of the wastes from the current generation of reactors? Will citizens and political leaders will be willing to buy the promise of a solution far in the future based on the creation of a large fleet of second generation, yet-to-be-tested, advanced nuclear plants and new fuel cycle facilities? Serious, sustained U.S. participation and leadership in international efforts to create the next generation of nuclear facilities and a secure new nuclear regime are needed. But not at the expense of a protracted delay or derailment of Yucca Mountain.

The U.S. repository program doesn't need nuclear power nearly as much as nuclear power needs the repository program. The reasons why the program is needed are no different than when the Congress passed the original Nuclear Waste Policy Act in 1982. Setting aside economics and technology issues, the rationale is straightforward public policy based on doing what is right. This generation is benefiting from the nuclear power and can and should meet its obligation to provide a clear and safe option for disposal. It should bear the political, institutional, and economic costs while preserving the ability of future generations to do what they see as in their best interests. Without a final environmental standard, the licensing of Yucca mountain cannot be considered a certainty. But keeping the program vibrant and moving it forward is important. Fortunately, an adaptively staged program can do just that.

Public Acceptance Derives from Trust

An adaptive approach also provides the best opportunity to address the major challenge of public acceptance. Many studies have been conducted to understand the causes of public trust or mistrust of controversial decisions. Nuclear waste management has frequently been the focus for obvious reasons. Often it is suggested that the lack of public acceptance and trust arise from insufficient public information and public involvement programs. Certainly such activities are necessary. But what waste management programs around the world demonstrate is that these efforts are necessary but not sufficient. Trust arises in repository programs for the same reasons people trust (or don't) their local police, fire departments, teachers, or political representatives.

Trust is more evident when the authorities are well known and have demonstrated three important features:

 The authority is seen as highly competent and a has demonstrated track record of competence;
 The authority is seen as caring about the affected community and making decisions with the communities best interests foremost in mind; and
 The authority engages the affected community and involved stakeholders throughout the process and is willing to modify program elements to respond to their concerns, rather than trying to talk them out of their concerns.

By staging a program, the implementing authority creates many opportunities to promise and deliver on program progress and content. Such a program is built on the premise that adaptation and flexibility are virtues and attributes that benefit both program implementers and stakeholders.

An essential feature of an adaptive staged approach is the way it addresses the most challenging scientific and societal challenges. It allows for full-scale disposal, but does not mandate the entire schedule or final disposition (which, in reality, it cannot do anyway). It provides future generations the prospect of a permanent solution, and importantly, the flexibility to do what they see as in their best interests at the time. If everything goes well, it is our grandchildren's grandchildren, not we, who will be

positioned to make an informed decision when and under what circumstances to close the repository.

The Coming Opportunity

There is one recent development on the horizon that may play an increasingly important role in shaping successful repository programs: security concerns. They are arising with the anticipated growth and spread of nuclear power and its associated fuel cycle capabilities. The fissionable materials used in nuclear weapons come from either uranium enrichment or the reprocessing of spent fuel to extract plutonium. From the beginning of nuclear power the dual use nature of enrichment and reprocessing have been well understood; the same facilities needed to make and process nuclear power reactor fuel can be modified to make weapons usable materials.

Recent initiatives have been proposed by many, including President Bush and IAEA Director-General Mohammed ElBaradei, to limit the spread of these sensitive nuclear facilities. An international network to provide assurances of fresh fuel and take back spent fuel could dramatically reduce or eliminate the need for additional countries to develop their own enrichment or reprocessing capabilities while fully preserving their ability to pursue nuclear power.

Of course, the promise of the return of spent fuel to the country of origin or to a third country does not eliminate and may heighten the issue of its ultimate disposition. Many features of such an arrangement will have to be carefully defined and developed before an effective international framework can be established. Nevertheless, this approach holds out the possibility of repositories being transformed from perceived waste dumps to integral elements of a security-based international network. The network could include regional or multi-national facilities and would provide developing countries with the ability to meet growing energy demand while reducing proliferation and security concerns. Doing the right thing may some day lead to greater public understanding and acceptance of the important role of repositories in realizing a world with adequate energy, environmental integrity, and enhanced security.

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