STRATEGIC ISSUES AND CHALLENGES IN SPENT FUEL MANAGEMENT

(Session 2)

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INTEGRATED STRATEGY FOR SPENT FUEL MANAGEMENT

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Abstract

Today, the United States of America rely on the Yucca Mountain geological repository for the storage of SF. In order to replace it, an integrated strategy is being elaborated by NRC, DOE and the new blue ribbon commission, initiated by the Obama administration. The strategy aims to update licensing, regulation and enhance research efforts in 3 inter dependant cores: transportation, reprocessing and waste disposal. The main goal is to bring a solution to environmental, social, security and safeguards issues. However, this integrated strategy is still under development, as many questions are yet to be answered.

I recently began serving in my present capacity as the Deputy Executive Director for Materials, Waste, Research, State, Tribal, and Compliance Programs. Before this, I served for three years as the Director of the Nuclear Regulatory Commission's Office of Nuclear Material Safety and Safeguards, where I lead regulatory programs for SF storage, transportation, fuel cycle facilities, high-level waste disposal, and domestic and international safeguards. Representatives from the NRC will be making several presentations throughout this conference. We welcome your candid feedback and suggestions on our regulatory programs, as well as opportunities to collaborate with our international partners on a bilateral and multilateral basis.

1. BEGINNING WITH AN ENDING

It can be interesting to begin a presentation like this with an "ending". The ending to which I refer is the United States Department of Energy's pursuit of the authorization to construct a geologic repository at Yucca Mountain in Nevada. In the U.S., the Department of Energy and the Nuclear Regulatory Commission prepared for the licensing review for over 20 years since the Congress selected the Yucca Mountain site as the exclusive first repository candidate in the Nuclear Waste Policy Amendments Act of 1987. The Department of Energy delivered the license application to the NRC in June 2008. After a careful acceptance review, the NRC staff accepted that application for review in September 2008 and the Commission commenced the hearing process in October of the same year.

Meanwhile, in May 2007, Senator Barack Obama, then candidate for the Presidency, wrote a letter to the editor of the *Las Vegas Review-Journal* that began with "I want every Nevadan to know that I have always opposed using Yucca Mountain as a nuclear waste repository…" The Senator described in his letter a variety of concerns about building a repository at Yucca Mountain. In October 2007, Senator Obama wrote to his colleagues in the Senate that "it is no longer a sustainable federal policy for Yucca Mountain to be considered as a permanent repository." Instead, he encouraged the Federal government to refocus its resources on finding more viable alternatives for the storage of spent nuclear fuel until a safe, long-term solution can be implemented. He concluded that letter by stating "…it is time to start exploring new alternatives for safe, long-term solutions based on sound science."

When he was elected President the following fall, many wondered how he would deliver on his commitment to pursue alternatives for the proposed repository at Yucca Mountain. In February 2009, barely five months after the NRC had accepted DOE's license application for review, the President and the Administration began translating their earlier commitments into policy and budget decisions that reflected their reluctance to move forward with Yucca Mountain. This reluctance took shape in the President's budget proposal in May 2009 by including the Yucca Mountain project on a list of government projects to be terminated. President Obama's position became even clearer in the proposed budget in February 2010, which accompanied an announced decision by the DOE to withdraw the Yucca Mountain license application and establishment of the Blue Ribbon Commission on America's Nuclear Future. The Blue Ribbon Commission is charged with conducting a comprehensive review of policies for managing the back end of the nuclear fuel cycle, including all alternatives for the storage, processing, and disposal of civilian and defense used nuclear fuel, high-level waste, and materials derived from nuclear activities. DOE submitted its motion to withdraw the Yucca Mountain license application on March 3, 2010.

The NRC's Atomic Safety Licensing Board began considering that motion along with new petitions to intervene in the proceeding from States, an Indian Tribe, a County, and the National Association of Regulatory Utility Commissioners. The NRC's Licensing Board suspended consideration of the motion to withdraw and the petitions to intervene until the U.S. Court of Appeals for the District of Columbia ruled on several challenges related to DOE's decision to withdraw its application. However, the Commission on April 23rd vacated the Board's suspension and directed the Board to rule on DOE's motion by June 1, 2010. The Board is now moving forward with the review DOE's motion. In fact, this week while we are meeting here in Vienna to discuss SFM, NRC's Licensing Board is conducting hearings on DOE's motion in Las Vegas and plans to render a decision on that motion by the end of June.

As these legal proceedings continue, the NRC staff's licensing review also continues in parallel. The staff is carefully reviewing DOE's license application against NRC's repository regulations in 10 CFR Part 63 and is moving forward in developing regulatory findings. Nevertheless, the funding and timeline for this review are beginning to play out. Absent direction to the contrary from the Commission itself, the courts, or Congress, the path that we are on will lead to termination of the licensing review far short of the goals that have been established in the Nuclear Waste Policy Act and in NRC's regulations in 10 CFR Part 2.

The ending of the Yucca Mountain licensing program will also leave the Nation with a dilemma. Although the SF remains safe and secure at more than a hundred nuclear power plant sites, not to mention the SF and high-level waste already being stored by the DOE at other locations around the country, the amount of SF and high-level waste continues to grow with each passing month and year as projected in this slide under a range of scenarios. All commercially viable nuclear fuel cycles contemplate the need for some permanent disposal capacity. Even under the most optimistic forecasts, which generally do not reflect reality when dealing with radioactive waste management, it will take a couple years for the Blue Ribbon Commission to consider the alternatives and recommend a path forward for the Nation and several more years of deliberation within the Congress to adjust the Nuclear Waste Policy Act accordingly. In the interim, the SF and high-level waste will continue to accumulate.

2. INTEGRATED STRATEGY

Although the amounts of waste continue to increase, one constant is our continued focus on ensuring safety, security, and environmental protection. This mission needs to be accomplished regardless of the uncertainties and variables that exist.

For this reason, the NRC staff began planning a couple years ago, as a contingency, the measures that would be needed to accomplish our mission if progress on Yucca Mountain were disrupted for a variety of reasons. Recent developments and announcements have turned up the gain and compressed the schedules a bit for our planning. My presentation here today presents an opportunity to share our planning with an accomplished group of stakeholders and to seek your candid feedback, concerns, and questions on the direction that we are heading.

In response to the recent changes in the national program for high-level waste management, the NRC has initiated a number of actions, including:

- Evaluation of the technical and regulatory requirements to support long-term dry storage of SF and deferred transportation of SF;
- Identification of regulatory gaps and development of a regulatory framework for reprocessing;
- Consideration of a revised waste confidence rulemaking;
- Development of revisions to NRC's regulatory and analytical tools to consider alternative waste disposal options.

3. LONG–TERM STORAGE

I mentioned long-term storage of SF, so what constitutes "long-term storage?" This is the first core area of our integrated strategy. The definition depends somewhat on the perspective of the person answering the question. It may be a bit like "beauty is in the eye of the beholder." If one is a nuclear utility who had contracted with the DOE to begin transferring the SF no later than 1998, the perspective might be that we are already at "very long-term storage." This perspective might resonate with residents living near a decommissioned nuclear power plant whose only remnant is the Independent Spent Fuel Storage Installation (ISFSI). Alternatively, if one is proposing to build a new nuclear power plant or renew the license of an operating nuclear power plant, very long-term storage could by considerably longer than the NRC has traditionally licensed dry storage, approaching 20 years or longer. When NRC uses the term, we are considering storage in excess of 120 years. The extended storage raises a series of questions about the adequacy of the technical and regulatory basis. What is the existing safety and environmental basis for licensing spent fuel storage? What issues arise when considering storage beyond the conventional periods? What information, research, evaluations are necessary to resolve these issues or confirm the adequacy of the existing basis? And who should do the work necessary to establish or extend this basis to ensure safety, security, and environmental protection?

Although most of the exploration of these issues to date has focused on safety issues, it is important to adopt an integrated approach in considering the solutions to environmental, social, security, and safeguards issues, as well. For example, if we strive to minimize the handling of SF after it has been placed in a multi-purpose canister, this could mean that fuel loaded in the next year might remain for many years, perhaps hundreds, before the canister is reopened, if ever. What assurances and controls are necessary to satisfy domestic and international safeguards obligations and requirements when the fuel is initially loaded? How do changes in the duration of SF storage shift the carefully hewn balances involved with societal and generational equity? Will SF placed in storage today be acceptable for transport tens to hundreds of years from now, and, if not, what additional assurances or measurements could be necessary to ensure safety and security when the fuel is ready to be shipped?

4. DEFERRED TRANSPORTATION

Obviously, with the alternatives under consideration by the DOE and the Blue Ribbon Commission, SF placed in storage may need to be transported for a variety of reasons, including direct disposal, consolidation in regional storage facilities, repackaging, or reprocessing. This means that the SF when it is transported will be considerably older than it would be if the planned repository had become available in about 2020. The aging of the fuel raises uncertainties about what information may be needed to provide sufficient confidence that the older fuel can be safely transported. If safety and security cannot be assured, then additional measures may be necessary prior to shipment, such as confirmation of cladding integrity or repackaging in over packs or other containers. It is important to consider these issues now to achieve durable solutions and to minimize the need downstream to conduct activities that will increase risk and radiation exposure associated with SF handling. What are these solutions? What issues are we aware of today that may need to be resolved in the future before commencing transportation of older fuel?

5. REPROCESSING

Another alternative that has been receiving increased attention in the United States during the last several years is reprocessing and recycling recovered uranium and plutonium from reprocessed SF. This is the second core area of our integrated strategy. During the Administration of President George W. Bush, in response to the Global Nuclear Energy Partnership, (GNEP), the NRC launched a project to re-examine the existing requirements that would apply to commercial reprocessing of SF. Although GNEP has been sunset domestically, support for exploring commercial reprocessing continues within the Administration and the private sector, which has encouraged the NRC to continue developing the regulatory framework for commercial reprocessing. In 2009, the NRC staff completed its analysis of regulatory gaps that exist in the requirements today, which could involve an issue that needs to be resolved to ensure safety, security, or environmental protection or that could impede the licensing review. We prioritized these gaps into high, medium, and low categories based on their significance to safety and security and their impact on licensing. Today, the NRC is developing the technical basis for a rulemaking or series of rulemakings that would overhaul the regulatory framework and close these gaps, at least the high priority gaps.

It is important to point out that the NRC is neither for nor against commercial reprocessing. We are for safety, security, and environmental protection, so if there is interest in applying for a license to build and operate a commercial reprocessing facility, our objective is to ensure that the regulations are in place to guide this licensing process. Ideally, any new regulations would be in place well in advance of the submission of a license application to encourage the submission of a high quality application. We also recognize that there are a variety of stakeholders with strongly held views on reprocessing, so we need to engage these stakeholders in an early and meaningful way to ensure that we understand these views and address them in proceeding with the rulemaking.

6. WASTE DISPOSAL

The third and final core area of our integrated strategy is waste disposal. Earlier in my presentation I provided a current description of the status of Yucca Mountain, including our licensing review. If Yucca Mountain is set aside as an alternative for disposal of HLW and SF, we expect that it will take decades of work to revise the national policy framework, enact the necessary legislation, evaluate alternative disposal technologies, revise and apply DOE's screening process for new disposal sites, characterize and engineer one or more disposal facilities, and prepare one or more new license applications to the NRC. Consequently, of the three core areas that I have described, we probably have the greatest lead time available in the area of waste disposal to refine our regulatory tools, revise the regulatory framework based on the lessons that we have learned during the last 60 years, and prepare to conduct another licensing review of a proposed disposal facility. Consistent with the Nuclear Waste Policy Act, our regulatory framework — including regulations, guidance, licensing procedures, and analytical tools — has been tailored to consider one potential geologic repository site that is located about 100 miles northwest of Las Vegas. It will take some time and effort to retool our regulatory framework, but that effort is likely far less than the effort and time that DOE or some other entity would require to prepare a disposal license application. By planning and working in this area now, we can leverage the capabilities that we have developed during the last several decades, while the memories are fresh, the context clear, and the experts are available. Consequently, we are planning a variety of knowledge capture and knowledge management activities as part of our closure plan if DOE succeeds in withdrawing the licensing application and shutting down the Yucca Mountain Project. As time progresses, our ability to leverage this knowledge and wisdom will diminish. To the extent that we can revise our regulatory tools sooner as part of these knowledge management activities while preparing to review future disposal alternatives, the NRC staff will be able to apply these tools sooner and provide advice to the Commission, the Congress, and other entities on the viability of disposal alternatives.

7. THE BENEFITS OF AN INTEGRATED APPROACH

As I have described our plans in these areas, I have characterized them as discrete efforts that align with our existing organizational structure within my office and with the NRC's regulatory framework in title 10 of the U.S. Code of Federal Regulations. The NRC sees great value in executing these plans in an integrated manner for a variety of reasons.

First, storage, transportation, reprocessing, and disposal do not occur in isolation or independently. Each step in the nuclear fuel cycle represents part of an integrated cycle, as a means to achieve the safe and secure beneficial use of nuclear energy. Consequently, it is important for NRC to develop and implement improvements to our regulation of these steps in an integrated manner to ensure that the steps remain compatible and so we keep the life cycle risks, benefits, and costs in perspective (focus on the forest, not the trees).

Second, evaluating and preparing our regulatory framework in an integrated manner allows the agency to leverage the technical and program interdependencies in accomplishing NRC's mission in a more effective and efficient manner.

Third, by conducting these preparations in an integrated manner, the NRC staff will share information internally that pertains to interrelated activities, as well as with external stakeholders, including industry and licensee representatives, public and other interested stakeholders, international counterparts, and Federal, State, Tribal, and Local government officials. Even in developing the plan for the integrated strategy, the staffs from the various offices recognized the interdependencies of regulatory actions that affect multiple steps of the nuclear fuel cycle. For example, decisions about allowable levels of burnup may need to consider the implications to the front and back end of the nuclear fuel cycle, in designing fuels and assessing storage technologies. Similarly, our planning to date has also identified the need to closely couple decisions about wet pool storage and preparations for dry storage, cask loading campaigns, and transportation.

8. MEASURING SUCCESS

So how do we plan to measure the success of our efforts that make up the integrated strategy? Our most important and most fundamental measure is continued safety, security, and environmental protection, not just for the SF after it has been irradiated in reactors, but also the other facilities and services that are used in the nuclear fuel cycle. Second, if we are successful, then NRC will be prepared to regulate effectively and efficiently under a broad range of potential scenarios. It is important here that we do not "overrun our headlights" and get so far ahead of industry, the Department of Energy, and national policy that we spend significant resources preparing to license and regulate technologies that may never see commercial development and operation in the United States. By the same token, however, we also need to develop regulatory frameworks, approaches, and tools that are sufficiently flexible to accommodate viable technologies in a timely manner. This means not waiting until all the dust settles in the current environment before embarking on the rulemaking, research, and process improvement initiatives that can take years to decades to successfully complete. If we do this right and remain in contact throughout the process with a comprehensive assembly of stakeholders, then the NRC will be prepared to respond to and support national decisions in a timely, effective, and efficient manner.

9. COMPONENTS OF THE INTEGRATED STRATEGY

What are the specific elements of our integrated strategy? In the next several slides, I spotlight broad categories of actions that comprise parts of the strategy in each of the core areas and in communications with stakeholders. In the licensing program, the NRC staff is revisiting the paradigm for SF storage and transportation consistent with direction from the Commission in February 2010. The objective of this element is to build from our strengths — a regulatory program that today is accomplishing safety and security, but could be enhanced to accomplish this work more effectively and efficiently, in a more risk-informed, performance-based manner, and in a manner that encourages creativity and the use of cutting edge technologies to accomplish the fundamental goals of safety and security. We are also reviewing the detailed licensing and inspection processes to enhance their effectiveness and efficiency in a coordinated, integrated manner. We are also beginning the development of more flexible regulatory tools, such as our performance assessment code for waste disposal, which will allow the NRC to consider alternatives to the geologic media, disposal method, and waste form that we had assumed for Yucca Mountain.

In the area of rulemaking, we are reviewing the existing requirements in Parts 71 and 72 to determine if the requirements should be combined or, if not, can the regulatory reviews that we rely on to confirm compliance with these requirements be combined. As part of this review, we are open to considering alternative approaches for certifying SF storage and transportation designs. Another component of our rulemaking work is in the development of the technical and environmental basis for reprocessing and preparing a proposed rule or rules that would substantially revise the regulatory framework for reprocessing. On a slower pace, we are also re-examining the adequacy of NRC's existing requirements for geologic disposal in Parts 60 and 63 to determine whether there are gaps that would need to be resolved for ultimate disposal of high activity radioactive waste.

The third component of our integrated strategy is research. This component includes development of the technical basis for resolving key aging issues associated with long-term storage of SF and deferred transportation. Parts of this component will also provide the basis for developing technical and regulatory guidance needed for reprocessing. The remainder of this component is focused on identifying potential issues associated with regulating advanced reprocessing technologies (beyond aqueous processing) and with different disposal media and methods.

Enhancing international collaboration in both multi-lateral and bilateral arrangements is another important feature of the integrated strategy. In today's global environment, we recognize that leveraging available knowledge and wisdom among both operators and regulators will contribute directly to resolve issues associated with long-term storage, deferred transportation, reprocessing, and disposal. This includes international collaboration on research, participation in multi-lateral activities, exchanging and assessing international operating experience, comparing domestic regulatory frameworks to encourage harmonization and application of international standards.

10. SUMMARY

We are still planning and developing our integrated strategy, which will likely continue as we identify opportunities for collaboration and leveraging work performed by other parties and as we adjust to the input from stakeholders and guidance and direction from the Commission and the Congress. The integrated strategy that I have described today should accomplish a number of significant benefits, including accomplishing our mission by leveraging limited resources in an effective and efficient manner, enhancing our ability to adapt to the changing national and international environment, and preserving the NRC's knowledge assets.

Thank you for listening. I wish for you a very exciting and productive conference. I'd be happy to answer your questions or listen to your comments and suggestions.

INDIAN STRATEGY FOR MANAGEMENT OF SPENT FUEL FROM POWER REACTORS

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Abstract

The boom of India's economy and population, and the determination to increase the nuclear share in the energy mix, will lead to a growing nuclear fuel demand. Regarding the limited known uranium resource within its territory, India will prefer to operate with a closed fuel cycle in order to improve the use of the already acquired uranium. This cycle will be based on the strategy to make efficient use of spent fuel in 3 consecutive steps: in PHWRs, in sodium cooled FBRs and with the thorium-uranium 233 cycles. However, in order to be efficient, India requires constructing infrastructure to reprocess fuel for those 3 stages, but also strategies to convey spent fuel to the reprocessing facilities.

Indian economy is growing at the rate of 8-9% per year and is likely to double its size every 8–9 years. Indian population is also growing and is expected to reach 1.5 billion by the year 2050. By the middle of the century, we also want to take our per capita energy consumption level to well above the world average consumption.

Nuclear energy is expected to meet 25–50% of the total requirement in the long term; the balance energy requirement is to be met from fossil, non-hydrocarbon (hydro and non-conventional) resources. This scenario will demand nuclear capacity addition of 200 GWe and more by the middle of this century.

On the resource side, known uranium reserve in India is adequate for an installed capacity of 10 GWe, which is sustainable for 30 years through the Pressurized Heavy Water Reactor (PHWR) route. Newer uranium finds will be utilized for extension of plant operating life to 60 years.

In once through cycle, utilization of uranium is limited to use of 1% of the total resource. By reprocessing Spent Fuel, it is possible to increase the uranium utilization by many folds. In this scenario closed fuel cycle operation is the only option for India. Spent fuel is a resource and in India fuel from all types of reactors need to be reprocessed.

The Indian three-stage Nuclear Power Programme envisages construction and operation of natural uranium heavy water based thermal reactors of PHWR type in the first stage. The Spent fuel from this stage is reprocessed and plutonium generated is fed to the second stage of the programme based on, fast breeder reactors. The Spent fuel from the Fast Breeder Reactors containing large amount of plutonium will be reprocessed after short cooling period and thus enabling, faster multiplication of the fast breeder reactor programme. In the third stage, Th-U^{233} based breeder reactors, with U^{233} obtained from blanket of fast reactors or Th-Pu-U^{233} fuel cycle, will be built. The spent fuel from these reactors will be reprocessed to generate more fissile material for enlarging the third stage of the programme.

With the signing of agreement of cooperation in nuclear field between India and other countries, it has become possible to install a large number of enriched uranium based light water reactors in India. The Spent Fuel from these reactors will be reprocessed under safeguards and plutonium will be utilized in fast reactors to be operated under safeguards. Slightly enriched uranium available after reprocessing LWR SF, will be used in PHWRs for power generation. The spent fuel from these PHWRs will be reprocessed under safeguards for extraction of plutonium. Nuclear cooperation agreement has also enabled us to procure natural uranium from foreign sources being used in PHWRs for power generation under safeguards. Spent fuel from these PHWRs will also be reprocessed for supply of Pu to the 2nd and 3rd stage of our nuclear power programme.

Spent fuel from thermal reactors involving low burn up (PHWRs) and high burn up (LWRs) fuel is reprocessed in aqueous reprocessing plants. Water cooled storage pools are used for facilitating the required amount of cooling for Spent Fuel prior to reprocessing. The Spent Fuel Storage pools also provide buffer storage capacity to cover the mismatch between time of discharge from reactor and subsequent reprocessing.

In case of fast reactor SF, cooling is carried out in the reactor itself and later transferred to water cooled pools, prior to reprocessing, after removal of sodium. Oxide fuel coming out of Fast Reactor is reprocessed in aqueous reprocessing plants. Metallic fuel used in fast reactors will be reprocessed by pyro chemical process/aqueous process.

Reprocessing of fuel from thorium fuelled reactors will involve three components Th-U^{233} –Pu and two component Th-U^{233} reprocessing. Handling issues related to U^{232} and its daughter products is a major consideration in the design and operation of Th-U^{233} based reprocessing and fuel fabrication facilities. Thorium coming out of this stage will need to wait for few years for decay of Th ^{228} and its daughter product before further use.

In India all reprocessing plants are located at coastal sites. To minimize transportation of fuel in the public domain; in future all integrated reprocessing, waste management and fuel fabrication facilities will be located in Nuclear Power Parks spread all over the country at coastal sites. Spent fuel transportation from power reactor sites, far away from reprocessing plants, will be done through land routes. The shielded casks and trailers used for transportation are designed and tested as per International Standards.

More detailed safety and security codes and guides are required, than is available today, for the back end of fuel cycle. These documents may cover reprocessing, waste management and ultimate disposal related issues. IAEA has a very major role to play in this area for improving the safety and security of these programmes.

In India, smaller size plants both for reprocessing and waste management of thermal and fast reactor spent fuel, are in operation and more such facilities are in advanced stage of construction/commissioning. However, the present activities in SFM are focused on construction of larger plants to be operated in commercial scale. They will integrate reprocessing — waste management — fuel fabrication facilities. These large plants aim at perfecting the existing technologies involved in the above areas and produce fuel in an economic manner. The above facilities, both for thermal and fast reactor spent fuel, will use aqueous process and will be based on extension of existing technology for the equipment design and manufacture and meet the highest standards of safety and security. The plants are also designed to reduce waste volume and aim at recovery of caesium etc. for other applications. Two such integrated facilities, one for thermal and the other for fast reactor SFM, are taken up for construction. Equipment based on newer technologies will be introduced in successive plants for longer plant life and further reduction in cost.

In future metallic fuel is planned to be introduced in fast reactors for higher breeding ratio. Pyro-chemical reprocessing and metallic fuel fabrication technology development is essential for commercial scale operation of these plants meeting the safety norms.

Countries planning large nuclear power generation capacity are likely to opt for closed fuel cycle as this would be most desirable option both from the point of uranium resource utilization and the management of nuclear waste. Indian SFM programme will cover operation of large facilities for wide variety of fuel covering various types of reactors in thermal and fast spectrum in closed fuel cycle mode.

NUCLEAR SPENT FUEL MANAGEMENT IN SPAIN

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Abstract

The radioactive waste management policy is established by the Spanish Government through the Ministry of Industry, Tourism and Commerce. This policy is described in the Cabinet-approved General Radioactive Waste Plan. ENRESA is the Spanish organization in charge of radioactive waste and nuclear SFM and nuclear installations decommissioning. The priority goal in SFM is the construction of the centralized storage facility named Almacén Temporal Centralizado (ATC), whose generic design was approved by the safety authority, Consejo de Seguridad Nuclear. This facility is planned for some 6.700 tons of heavy metal. The ATC site selection process, based on a volunteer community's scheme, has been launched by the Government in December 2009. After the selection of a site in a participative and transparent process, the site characterization and licensing activities will support the construction of the facility. Meanwhile, extension of the on-site storage capacity has been implemented at the seven nuclear power plants sites, including past reracking at all sites. More recent activities are: reracking performed at Cofrentes NPP; dual purpose casks re-licensing for higher burnup at Trillo NPP; transfer of the spent fuel inventory at Jose Cabrera NPP to a dry-storage system, to allow decommissioning operations; and licence application of a dry-storage installation at Ascó NPP, to provide the needed capacity until the ATC facility operation. For financing planning purposes, the long-term management of spent fuel is based on direct disposal. A final decision about major fuel management options is not made yet. To assist the decision makers a number of activities are under way, including basic designs of a geological disposal facility for clay and granite host rocks, together with associated performance assessment, and supported by a R&D programme, which also includes research projects in other options like advanced separation and transmutation.

1. INTRODUCTION

The Spanish policy on radioactive waste and SFM and on decommissioning of nuclear installations is defined by the Government through the Ministry of Industry, Tourism and Commerce (MITC), and described in the Cabinet approved General Radioactive Waste Plan (GRWP). The 6th GRWP was approved in 2006 [1]. The nuclear safety and radiological protection authority, Consejo de Seguridad Nuclear (CSN) is independent from the Government. ENRESA is a state owned company having by law [2] the responsibility of radioactive waste management and nuclear installations decommissioning.

Spain has eight nuclear power reactors in operation in seven sites, with a total power of 7.73 GWe, and two reactors permanently shut down in different stages of the decommissioning process. Vandellós I NPP has a graphite-gas reactor, closed down in 1989. All its spent fuel was sent to France for reprocessing and some high and medium radioactive waste packages should return to Spain in the next years. Before 1982 spent fuel from Jose Cabrera and Garoña NPP was sent to the United Kingdom for reprocessing. Since 1985 all the spent fuel from light water reactors has been stored on site. The total amount of spent fuel stored in seven sites is around 3800 tons of uranium (tU), and the total foreseen amount of spent fuel with the hypothesis of the 6th GRWP — i.e. 40 year operation of NPP — reaches 6700 tU of spent fuel.

2. GENERAL ASPECTS OF THE SPENT FUEL MANAGEMENT POLICY

The priority for SFM is the construction of a centralized storage facility for all the Spanish spent fuel and other high and medium level waste that should return from reprocessing Spanish spent fuel or arise from Spanish nuclear plants decommissioning.

For planning and financing purposes direct disposal of spent fuel in deep formations is considered as the basic solution, although other options such as reprocessing advanced separation and transmutation that may significantly alter the basic scenarios are addressed. The 6th GRWP asks ENRESA to perform reports on:

- Generic Basic Design of deep repositories in granite, salt and clay, gathering the existing information from previous developments (favourable siting areas, conceptual design, associated performance assessment exercises, coordinated research work) and definig further needs;
- SFM options, considering international evolution, advances on research work, etc;
- Separation and Transutation feasibility, based on international developments and national research efforts.

It is recognized that social and technological development during a number of decades will be required for implementing any option, thus interim storage being a necessity. For periods of some decades, security and safety goals may be reached more efficiently in a single site for the whole country than scattered in seven sites (or eight if one considers the need of an individual facility for wastes to be returned from Vandellós I fuel reprocessing). As a consequence, the construction of the Centralized storage facility is the focus o the policy in this field, not neglecting the maintenance of capabilities in the fields required for further steps. In addition, some actions have been needed in various NPP sites to deal with their fuel management needs while the ATC might be commissioned.

3. ACTIONS IN DIFFERENT NPP SITES

In the 1990s, an extensive reracking programme was implemented in most of the Spanish NPP sites. Nevertheless, additional activities have been needed to increase the spent fuel interim storage capacities in the last years:

- Re-racking at Cofrentes NPP;
- Additional dual purpose casks and licence extension for the Trillo NPP Individual Storaghe facility;
- Individual Independent Storage facility at Jose Cabrera NPP;
- Individual Independent Storage facility for Asco 1 & 2 NPP.

In 2009, the storage capacity of Cofrentes NPP (BWR) has increased from 4187–5387 positions after rearacking its East fuel pool, thus providing enough room until the 2019 reloading, without utizing the full core reserve.

Trillo NPP has an individual independent storage facility in operation since 2001. The spent fuel elements are stored in dual purpose metal casks ENSA-DPT, licenced for storage and transportand suuplied by ENSA. The license as been reviewed to increase the maximum burnup from the previous 45–49 GWd/tU, in order to respond the higher burnup foreseen in this and other reactors. ENSA-DPT cask has capacity for 21 fuel elements PWR.

Jose Cabrera NPP closed down in April 2006 and has been turned over to ENRESA to perform the Decommisisooning Plan in February 2010. For doing that, one of the requirements was to defuel the nuclear fuel pool, located inside the reactor containment building. ENRESA ordered Holtec International a dry storage system, which was licensed in Spain by ENRESA. Jose Cabrera NPP utility licenced and built an Individual independent storage facility to which the total inventory of 377 spent fuel elemnts (100.5 tU) was succesfully transferred, ending in September 2009. The major challenges in this operation were the limited space in the reactor building and the equipment hatch, that required a very careful planning; the late in depth characterization of the fuel elemnts, changing in a few cases from intact to non intact and so altering the loading plans; and the need to accomodate 100% of the inventory. Figure 1 shows a general view of the of the storage pad with the 12 storage modules where the fuel canisters are stored.

Asco 1 and 2 would complete the capacity of the pools in the fuel buildings by 2013 and 2014 respectively. Then a storage system, similar to the one selected for Jose Cabrera to provide room for the NPP needs. ENRESA has applied for the system design approval and Asco utility has pplied for the construction licence of the storage pad and has initiasted the Environmental Impact Statement procedure to start the construction next year.

FIG. 1. Trillo NPP dry storage containers.

4. THE CENTRALIZED STORAGE FACILITY (ATC)

4.1. The Technological Park and the Centralised Storage Facility

The project consists of three main elements:

- The Storage Facility itself;
- A Technological research centre and
- A business park.

This threefold approach will assist local and regional development, encouraging business implementation in the area on the one hand, and will also give an opportunity to enhance country research in the nuclear spent fuel and high-level waste behaviour fields, to support further management steps, on the other hand.

The facility has been designed to meet the technical criteria of 10CFR72 [3] with envelope site characteristics. Specifically it has been designed to:

- Maintain sub-criticality;
- Maintain confinement of radioactive material;

- Ensure radiation rates and doses for workers and public do not exceed acceptable levels and remain ALARA;
- Maintain Retrievability;
- Provide for heat removal as necessary to meet the above mentioned safety functions.

The selected technology for spent fuel and high level waste storage is dry-storage in drywells, providing double confinement (canisters and wells), providing the best conditions for storage during decades and cooling by passive means — i.e. natural convection. Figure 1 shows the conceptual design of the facility.

The facility will also include a storage building for medium level waste and the fuel and waste laboratory of the technological centre. This laboratory will contain hot cells and equipment for characterisation and behaviour of spent fuel rods in long-term storage and disposal conditions.

FIG. 2. Conceptual Design of Centralized Storage Facility (ATC).

4.2. Site selection process

The Industry Commission of the Spanish Parliament unanimously recommended to the Government, in 2004, the development of a centralised storage facility for the Spanish spent nuclear spent (SNF) and high-level radioactive waste. In 2006, the Parliament urged the Government to set an Inter-ministerial Commission to define the criteria and supervise the site selection process on a transparent, democratic and participative basis. This Commission is presided over by the Secretary of State of Energy and has representatives from the ministries of Industry, Environment, Science, Economy, Public Administration and Health. In the same year an information campaign directed to all the municipalities in the country was carried out. This campaign included publicity in all the newspapers, publication of information in the webpage of the Commission, answering the questions from the municipal councils and general public, etc. The Spanish Secretary of State of Energy launched in December 2009 [3] a public call for candidate municipalities to host the Centralised Interim Storage Facility for nuclear spent fuel and high level radioactive waste.

This planned facility has been designed to receive and store for decades all the spent fuel from the Spanish power reactors and the high level vitrified waste and long-lived intermediate level waste generated in the reprocessing of Spanish fuel abroad or in decommissioning power reactors. This period is judged sufficient to allow for technical and social development that would make possible the definition of strategies for a longer-term management options.

ENRESA is supporting the Commission with the required technical studies and providing information to the different stakeholders. It is also responsible for the design, construction and operation of such facility and, thus, the implementer of the described policy. Moreover,

5. ASSOCIATED RESEARCH AND LONG-TERMS ASPECTS OF SFM

ENRESA R&D previous programmes put much effort in deep disposal issues, organized and justified from performance assessment exercises associated to different conceptual designs in granite, clay and, in a lesser volume, in salt. The R&D programme has evolved following the GRWP trends. The stress in justification of the deep disposal option has been reduced, although some effort is devoted to maintain teams and competences, among other reasons supporting the decision making on options may be considered as an n important aspect. The research work is more focussed in supporting activities that already might be considered as in an industrial stage, in considering prolonged storage timeframes. The Technological centre foreseen as a part of the ATC complex will give momentum to the research work in the spent fuel field.

The ATC will provide enough time to make decisions on future options for SFM, taking into account the technological and social aspects and will also provide an opportunity to enhance the research effort in irradiated fuel extended storage, final disposal and other management options.

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MANAGEMENT OF SPENT FUEL IN GERMANY

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Abstract

This presentation gives an overview on the inventory of radioactive waste and spent fuel in Germany, the state of commissioning of the on-site storages for spent fuel and the balance of reprocessing of spent fuel.

1. INVENTORY OF SPENT FUEL

In Germany 17 nuclear power plants are still in operation. Depending on the respective power of the reactors an amount of 15–30 tonnes of heavy metal per year are unloaded from each reactor. This results in a total amount of about 350 up to 400 tonnes per year.

Since the commissioning of the first nuclear power reactor in 1966 until the end of 2009 a total of about 13000 tonnes of spent fuel has been produced including about 180 tonnes from experimental and prototype reactors.

The major part of the fuel has been shipped to other locations for reprocessing, a total of 6670 tonnes. About 6,430 tonnes were stored in particular the reactor pools or in dry storage facilities. When the last reactor will be shut down in the year 2022, a total amount of 17200 tonnes will have been produced during 60 years of nuclear power generation in Germany.

At the end of the year 2009, roughly 6430 tonnes of spent fuel were stored in domestic wet or dry storage facilities. 3420 tonnes (53% of the quantity) were stored in wet storage pools, particularly in the reactor buildings. The remaining 3,010 tonnes (47% of the quantity) were stored in casks at dry storage facilities. The vast majority of those fuel assemblies that are no longer stored in Germany were shipped to La Hague, Sellafield and Mayak for reprocessing.

If you have a look at the timely development of cumulated spent fuel arising in the time period from 1990–2025 you can clearly see that the stored inventory increases continuously after the legally forced termination of spent fuel shipments to reprocessing plants after the year 2005. The shipments to the reprocessing facilities were based on contracts that had been concluded in 1979 and once more in 1989 by the German utilities with COGEMA and BNFL covering the reprocessing of spent fuel assemblies from German nuclear power plants. The contracts contained obligations to take back radioactive wastes and the separated plutonium. A relatively small amount of spent fuel (nearly 200 tonnes) had been reprocessed between 1971 and 1990 in the domestic pilot reprocessing plant at Karlsruhe.

The largest part, about 5360 tonnes, has been brought to France. 850 tonnes have been shipped to the United Kingdom and a very small quantity was reprocessed in Belgium.

The radioactive waste streams that will return to Germany started in 1996. According to the spent fuel amounts the largest part of waste comes from France. Roughly 80% of the vitrified high active waste from the reprocessing of spent fuel from German nuclear power plants in France was shipped during the last years — from 1996–2008 — to the interim storage facility in Gorleben (85 casks with 2408 canisters). It is planned to ship the residual vitrified waste from France back to Germany until 2011 — exactly 11 casks in 2010 and the last 11 casks up to the end of the year 2011. Shipments from the UK are expected to start in 2014.

2. BALANCE OF REPROCESSING

The very first shipment to the reprocessing facilities La Hague in France and Sellafield in United Kingdom started in 1973. The final delivery of spent fuel assemblies was terminated on July 1th, 2005. This will ensure that during the remaining operation time of the German nuclear power plants the recovered plutonium will be in total processed into mixed-oxide (MOX) fuel assemblies and subsequently irradiated in the existing nuclear power plants.

With regard to the quantities of spent fuel contracted for reprocessing between the German utilities and the reprocessing plants of Cogema (5400 tonnes) and BNFL (840 tonnes), most of the separated plutonium will arise in France. About 40 tonnes of fissile plutonium will be separated by reprocessing of German spent fuel. About 965 tHM of fresh MOX fuel are already or will be fabricated from these 40 tHM of fissile plutonium. After reuse in nuclear power plants in Germany, which have a license to use MOX, the spent MOX fuel will be stored until final disposal. The reuse of plutonium as MOX fuel in the past and in the future is the basis for a step by step reduction of the German plutonium inventory.

From the current point of view, a delay might only be caused by problems in MOX fuel fabrication in the UK. The transfer of all separated German plutonium in MOX fuel elements will be finished by 2014 or 2016. The last MOX fuel elements are expected to be unloaded by 2020. All separated plutonium will then be embedded in spent MOX fuel assemblies.

3. ON-SITE STORAGE FACILITIES

By the end of 2003, nuclear licences had been granted for on-site storage facilities for spent fuel assemblies at twelve nuclear power plant sites. They are designed as dry storage facilities in which transport and storage containers loaded with spent fuel assemblies are emplaced.

Starting in 2007, all these on-site storage facilities went into operation. In 2005, the operator of the Obrigheim nuclear power plant applied for a licence for dry on-site storage of a small number of 15 casks. The licensing procedure is not finished yet.

The Federal Office for Radiation Protection is the competent authority for the licensing of spent fuel storage facilities. According to Section 6, para. 2, no. 4, Atomic Energy Act, it has to be proven that necessary protection against external events exists. This includes the crash of a large aircraft onto the spent fuel storage facility. Expert calculations — carried out as a reaction to the events of September 11^{th}, 2001 — proved that in case of the crash of a large aircraft safety can be guaranteed.

The evaluation of the safety assessment by the licensing authority is the basis for the final decision on the license. According to the Nuclear Licensing Procedure Ordinance, the siting and design have to be considered in the safety report. Site-specific evaluations refer e.g. to possible impacts on the facility due to potential hazardous activities in the vicinity, radiological impacts, and environmental impacts from the construction or the operation of the facility.

The licences of all German spent fuel storage facilities encompass several licensing conditions which have to be fulfilled before or during construction of the facility and which have to be considered during operation. They refer e.g. to regular checks of the cask monitoring system, approval of maintenance programmes, or detailed proof of cask repair measures. Compliance with these conditions is controlled by the competent supervisory authority. In case of any relevant changes in operation or construction or if substantial deviations from the licensed status occur, a modification license is necessary which requires also a revised safety assessment. Changes in cask design or spent fuel burnup are examples that require a revision of the safety assessment.

The capacities of the storage facilities are different. Limitations exist for the duration of storage, the number and type of fuel casks, the thermal capacity and the total activity. These limits are laid down in the technical acceptance requirements for the storage facilities. For each storage facility, the cask types and the characteristics of the spent fuel elements like burnup, initial enrichment, heat production limits, dose rate at the cask surface, leak-tightness and so on are specified.

Two different design concepts for the storage building, the WTI and the STEAG concept are applied for the storage of spent fuel in Germany. The two concepts are not fundamentally different but represent alternatives of the same basic concept. The main differences are the alignment of the storage areas and the thickness of the walls and the roof. The main criteria for the choice between the two alternatives probably have been the existing operational experience and the potential future use of modified storage containers. Proponents of the WTI concept argue that this concept has positive operational experiences of about 15 years at the storage facilities in Ahaus and Gorleben and that this experience was the basis for technical and economical optimisation.

On the other hand, the STEAG concept with its higher wall thicknesses for the storage hall was developed with regard to the future use of a new and more economical container generation. While currently the casks themselves already assure safety in case of an airplane crash, the utilities intend to take credit of the thick concrete walls when potentially implementing cost-saving cask generations in the future.

The use of either the STEAG concept or the WTI concept was the decision of the applicants. Both concepts fulfil the requirements for the safe storage according to the Atomic

Energy Act. The transport and storage casks guarantee that the main safety criteria are met. The main function of the storage hall is to provide protection against weather conditions and to assure heat removal. It should be noted that beside the STEAG and WTI concepts an individual tunnel concept is being used at Neckarwestheim. This special underground solution was developed to accommodate the specific site situation of the nuclear power plant.

The licensing requirements for the storage facility of spent fuel from VVER-440 reactors in the eastern part of Germany were the same as for spent fuel from other reactors.

The transport and storage casks for VVER-440 spent fuel assemblies are licensed or approved according to the German transport regulations which are fully consistent with the IAEA transport regulations TS-R-1. These casks have a type B(U)F package design approval certificate which must be valid over the whole interim storage period to allow transportation when necessary.

The last spent fuel assemblies from the wet storage facility (Central Waste Storage Nuclear Fuel) in Greifswald were transferred to the ZLN dry storage facility at the same site in 2006.

THE REQUIRED LEVEL OF DESIGN OF WASTE PLANTS FOR NEW BUILD REACTORS IN THE GENERIC DESIGN ASSESSMENT

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Abstract

The generic design assessment (GDA) process allows a rigorous and structured assessment of detailed Safety, Security and Environmental aspects of the design of new build reactors. For GDA the design of the fuel pond within the reactor building and the ILW processing facilities needs to be in sufficient detail to allow a fully detailed assessment. This paper clarifies the minimum position for GDA so that the output is meaningful and without exclusions. A separate paper will be developed for phase 2. For the other storage facilities, we need confidence through the GDA process that the spent fuel and waste can be retrieved, transported, and disposed of at the end of storage. Therefore the emphasis is less on the specific design details and more on the evidence to show that the chosen route is suitable. For the waste facilities, we need the Requesting Parties to demonstrate that they can safely handle, store and dispose of the wastes they generate. This will require sufficient levels of design to justify credibility of the storage options proposed; understanding how waste streams and their packaging evolve over the storage period; data and records management; knowledge of the constraints placed on the wastes by the disposal facilities; identification of knowledge gaps and the resulting R&D programme; and robust estimates of the required capacity. This paper proposes that for these other storage facilities the details discussed above are incorporated into a strategy that includes key milestones. This detailed strategy would satisfy the needs of GDA. The detailed review of the storage requirements will underpin the plans. This will include: i) the types of facility that could be used; ii) when facilities will be developed and constructed; and iii) the research needs that are required to ensure the waste and spent fuel can be safely managed on sites, transported and disposed of. These planning requirements are similar to those that both the Regulators and the Nuclear Decommissioning Authority (NDA) are adopting for legacy sites. Therefore, requiring the Requesting Parties to adopt similar approaches to the existing Nuclear Site Licence Companies will provide the level of information required by the Regulators and give synergies across the UK nuclear industry. It will also allow the Operators and Requesting Parties to incorporate knowledge gained across the industry as the waste management techniques develop, to make use of best available techniques and provide a cohesive inter-generational UK strategic approach to waste and SFM.

1. INTRODUCTION

The Generic Design Assessment (GDA) process allows a rigorous and structured assessment of detailed Safety, Security and Environmental aspects of the design of new build reactors. This paper clarifies the strategy for waste facilities in the generic Design Assessment (GDA) process. The Environment Agency, Department for Transport and Health and Safety Executive’s Nuclear Directorate has developed the paper.

2. BACKGROUND

The management of radioactive waste in the UK has developed over the last sixty years. A recent change was the establishment, by government of the Nuclear Decommissioning Authority (NDA). Its mission is to deliver safe, sustainable and publicly acceptable solutions to the challenge of nuclear clean-up and waste management. Of interest are the Lifetime Plans required from operators and development of a disposal facility:

- The Lifetime Plan, or equivalent, is the over-arching document that describes the totality of activities required to take the site from its current state and mission to the assumed or agreed site end-state;
- In 2006, the government gave the role of repository development to the NDA. Subsequently the NDA created the Radioactive Waste Management Directorate. The directorate's role is to develop and implement a Geological Disposal Facility for the UK's higher-activity wastes. As part of this, they are looking at whether the Geological Disposal Facility can accommodate wastes from new build reactors.

The development of the geological disposal facility is an aspect of government's Managing Radioactive Waste Safely process. This is an open process involving a significant amount of public participation. As part of this process, the government established the Committee on Radioactive Waste Management to provide independent scrutiny and advice on the UK's management of its solid radioactive waste, including wastes from new build; plans for interim storage; and geological disposal of higher activity waste.

The approach to management of radioactive wastes in other countries is diverse. The selected examples indicate the range of approaches to SFM:

- In Finland, spent fuel is stored at the reactor sites pending disposal in a repository. Final disposal of spent fuel is anticipated to commence in 2020 (for more information see http://www.posiva.fi/en);
- In France, spent fuel is initially stored at the reactor site before transport to Le Hague for reprocessing (See http://www.irsn.org/en/index.php for more information);
- In USA, following the announcement by President Obama about the future of Yucca Mountian the US government is reconsidering the national SFM strategy.

The range of international approaches to waste and SFM generally reflect the availability (or not) of final disposal sites. When reviewing international experience it should be remembered that the LLW and ILW activity classification systems may differ from those used in the UK. Therefore it is not possible to identify a situation that is directly analogous with the situation in the UK.

Within this context the UK government is ensuring that operators estimate the full costs for decommissioning and waste management through the Funded Decommissioning and Waste Management Programme (FDWMP). This requires the operator to provide for the steps necessary to decommission and manage and dispose of radioactive waste. The information produced by the Requesting Parties on waste management for GDA can also be used to inform the work on FDWMP.

3. EXPECTATIONS OF GDA

The GDA process allows a rigorous and structured assessment of detailed Safety, Security and Environmental aspects of the design of the reactor. At the end of the assessment, we will confirm whether the Requesting Parties have adequately addressed these aspects within their designs.

For the waste facilities, we need the Requesting Parties to demonstrate that they can safely handle, store and dispose of the wastes they generate for the whole lifecycle of the reactor. This will require sufficient levels of design to justify credibility of the storage options proposed; understanding how waste streams and their packaging evolve over the storage period; plans for data and records management; knowledge of the constraints placed on the wastes by the disposal facilities; and robust estimates of the required capacity.

The documents published as part of GDA request designs for waste management facilities, but do not specify the amount of detail required in the design. In 2008 Regulatory Issues were raised on each Requesting Party about waste management, these stated similar expectations. More recently, two Technical Queries to EdF/Areva outlined aspects to address in the design of storage facilities. To support these interactions this paper clarifies the Regulators' expectations for the level of design required in the GDA submissions.

4. DISCUSSION

Waste storage and processing facilities at a reactor fall naturally into four general areas, these are:

- The spent fuel storage pond within the reactor complex used for loading and unloading fuel and initial cooling;
- The facilities for the longer term storage of the spent fuel;
- The facilities for management and processing of LLW and ILW wastes; and
- The storage facilities for ILW.

The figure below outlines when these facilities are likely to be required and their probable lifetimes. It is noted that there will be a requirement for export/transport facilities at the end of the storage period. In this paper it is assumed that these aspects are part of the bars related to storage.

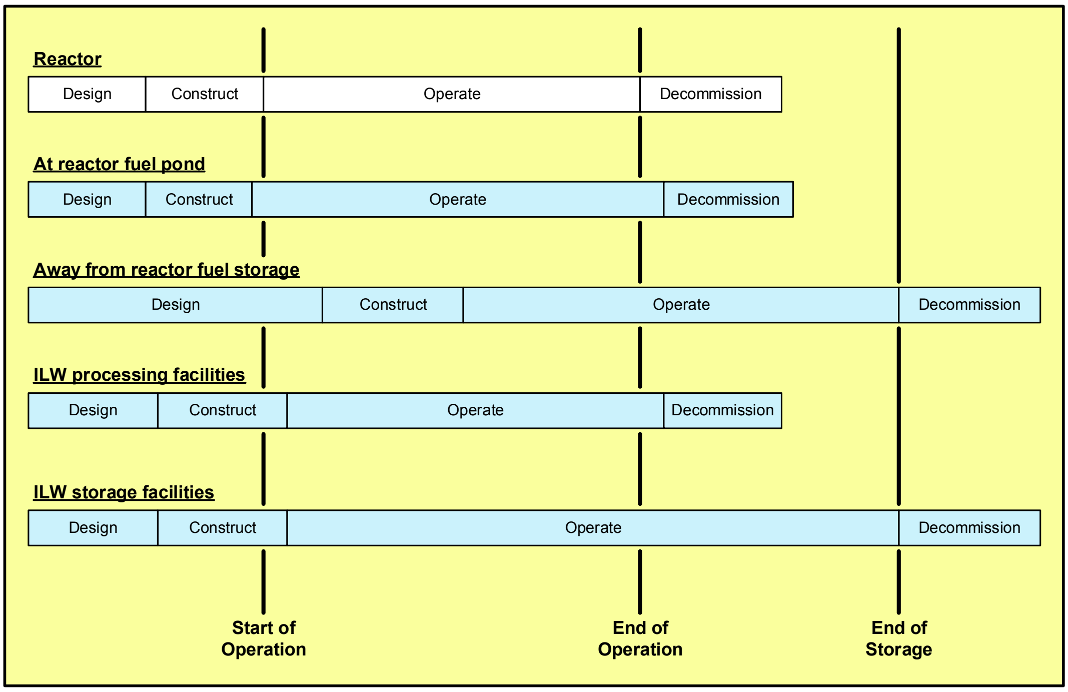

FIG. 1. Possible lifetimes for waste facilities at a reactor.

It is clear that for each of the facilities different levels of design are likely to be acceptable at the end of GDA.

The at-reactor fuel ponds are an integral part of the reactor building and are needed early in the reactors life. It is a facility common to other reactors in the UK or overseas. Therefore, their development should be to the same level of design as the reactor, within the same timescales. So this paper does not consider the at reactor fuel pond further.

Facilities for processing[1] ILW and LLW are available and have been used in the UK. The processing is fundamental to the safety, transport and environmental effects of storage and disposal of the wastes. The mobile units suggested in the submissions are currently in use. Therefore, the development of the processing facilities should be to the same level of design as the reactor, within the same timescales. So this paper does not consider the ILW processing facilities further.

The two remaining areas are the away from reactor fuel storage and the ILW storage facilities. These are areas where:

- Operators will optimise designs against their own strategic objectives. For example, if an operator uses a standard approach to waste management across their reactor fleet they may want to apply the same approach to their UK reactors. This is outside the control of the Requesting Parties;

[1] In this case processing can mean all the activities undertaken on the waste up to the point when conditioned waste is placed in storage, for example storage of raw waste and segregation prior to conditioning would be covered by the term processing.

- Operators and Requesting Parties need to understand the evolution of the spent fuel or waste to specify storage facilities, data and records management and any inspection procedures necessary to underpin the safety cases for storage and/or transport;
- In the early development of the facility, the Requesting Parties and the Operators need to develop designs in sufficient detail to understand the interface with the reactor and the export facilities; show how to refurbish key equipment; and the types of potential failure or degradation in the waste or spent fuel; the consequential effects upon the storage and transport safety cases and the options available for managing these.

As can be seen from figure 1 the requirement for an Away From Reactor Fuel Store is a significant period after the reactor starts operation, because of the capacity provided in the At Reactor Fuel Pond (typically 5–15 years). Within this period, there will be more experience of long-term storage and disposal. Therefore, Operators will be able to take account of changes in SFM practices and have a clearer specification for disposal. To give the Regulators the required level of confidence that the operators can safely handle, store and dispose of spent fuel viable options will have to be identified by the Requesting Parties and a strategy/plan developed to show that one of these could be developed and implemented. This will allow a conclusion at the end of GDA that the management of spent fuel has been adequately addressed.

ILW stores will be required on a shorter timescale. There are examples within the UK of stores built for this type of waste with design lives of at least 50 years. Therefore, we can be confident that the reactor operator can develop a suitable store, as credible designs are available. The more challenging issues are the size and location of the stores. For example, the amount of ILW will increase significantly when decommissioning the reactor, so should an operator build a store for all wastes, or a small store now and a larger one when the site is decommissioned? The public will want these issues debated. Therefore, as part of GDA we should encourage the Requesting Parties to look at all possible options that are consistent with the governments base case for new build.

The storage facilities that the NDA is developing for legacy wastes face similar problems. Therefore, there are synergies with the NDA approach that Requesting Parties and potential Operators should look at exploiting.

The NDA is developing their approaches in recognition of the availability of their resources and the repository. For example, the lifetime plans are looking at the scheduling of wastes to the repository to give realistic lifetimes for different stores. The lifetime plans are comprehensive; at their heart are the Detailed Volumes. The Detailed Volumes contain the key information relating to the scope, schedule and costs of the lifetime work programme to be undertaken on the site. Therefore, the Detailed Volumes should contain a similar level of information to that required in GDA.

The Department for Transport also has an interest in the characterisation and conditioning of waste streams, data and records management, storage environments and regimes, packaging design, and monitoring and inspection regimes as waste and spent fuel will be eventually transported in the public domain. Furthermore, in view of the significant timescales involved, they wish to know the main constraining factors, consequential effects, and risk mitigation plans associated to meet a possible need to transport off site at any point in time during the reactor operating window, during the subsequent shutdown period, and during the decommissioning phase. The development of a strategic plan will allow incorporation of the requirements of the transport case into the plan.

5. CONCLUSION

The regulators need to ensure that the provision of information on waste management issues in GDA is proportionate, compliant with the regulations and consistent with public expectations. It is in the Requesting Parties interest to provide this information so that the conclusions at the end of GDA are meaningful and without exclusions.

For the at-reactor fuel pond and the ILW processing facilities, this is simply a case that we require a detailed design for detailed assessment in GDA.

For the other storage facilities, we can be more flexible. For the waste facilities, we need the Requesting Parties to demonstrate that they can safely handle, store and dispose of the wastes they generate. This will require sufficient levels of design to justify credibility of the storage options proposed; understanding how wastes evolve over the storage period; knowledge of the constraints placed on the wastes by the disposal facilities; and robust estimates of the required capacity. So for the other storage facilities detailed plans showing key milestones can satisfy the needs of GDA. A detailed review of the storage requirements will underpin the plans. This will include:

- The types of facility that could be used;
- When facilities will be developed and constructed; and
- The research needs that ensure the waste and spent fuel can be stored, transported and disposed of.

These planning requirements are similar to those of the NDA for legacy sites. Therefore, requiring the Requesting Parties to adopt similar approaches to the Site Licence Companies will provide the level of information required by Regulators and give synergies across the UK nuclear industry. It will also allow the operators and Requesting Parties to incorporate knowledge gained across the industry as the processes develop.

LONG-TERM MANAGEMENT OF SPENT FUEL IN CANADA

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Abstract

This paper will focus on the development of Canada's policy for the long-term management of Canada's spent nuclear fuel and the specific plans Canada has for implementing that policy.

1. INTRODUCTION

The nuclear industry in Canada has produced 42,000 tonnes of spent fuel. The majority of this material has arisen from 20 nuclear power reactors in the province of Ontario, one nuclear power reactor in Quebec and one nuclear power reactor in the province of New Brunswick. Smaller quantities have been produced by a number of demonstration and research reactors in Quebec, Ontario and Manitoba. All spent fuel is currently safely stored on the site where it was produced. The safety record of interim storage systems has been extremely good and nuclear power plant operators have adequate future capacity. With care and maintenance, interim storage structures could safely store spent fuel for many decades to come.

FIG. 1. Nuclear fuel waste sites in Canada.

2. HISTORY OF CANADA'S LONG-TERM SFM

The Canadian program for the long-term management of spent fuel was initiated in the 1980s as a result of the growing nuclear power program in Ontario. The governments of Ontario and Canada established the Canadian Nuclear Fuel Waste Management Program where Atomic Energy Canada Limited (AECL) was assigned the responsibility for developing geological disposal.

By the mid-1980s AECL's technological development program was considered a world leader. However, partly as a result of borehole testing being interpreted as siting, the two governments responded to public concern by referring the concept of geological disposal to the Federal Environmental Assessment Panel. A moratorium was placed on any siting activity pending this review. The Panel conducted a comprehensive review of the disposal concept that included Canada-wide public hearings. In its 1998 report, the Panel concluded that technical safety of geological disposal had been demonstrated at conceptual level but public support had not been demonstrated and there was insufficient social acceptability to proceed. The Panel made 52 recommendations that were largely accepted by government.

The main progress since the 1998 Panel report has been the passing of the Nuclear Fuel Waste Act (NFWA) and the formation of the Nuclear Waste Management Organization (NWMO) in 2002, the approval by the Government of Canada in 2007 of NWMO's recommended plan known as Adaptive Phased Management (APM), and the initiation of a process for selecting a site for a deep geologic repository (DGR) for long-term management of spent nuclear fuel.

3. 2002 NUCLEAR FUEL WASTE ACT

The NFWA required Nuclear Energy Corporations to form and fund the NWMO and to establish and contribute to trust funds. The Act required the NWMO to conduct a study of alternatives, make a recommendation to the government and then to implement the government decision. It also required the NWMO to define contributions to be made by the waste producers to trust funds and to report annually to parliament through the Minister of Natural Resources Canada. The role of the Government of Canada is to select one of the possible approaches identified by the NWMO, to approve trust fund contributions and monitor progress of NWMO, and oversee compliance with the Act.

4. NWMO STUDY OF ALTERNATIVES (2002-2005)

As required by the NFWA, NWMO initiated a study of alternatives in 2002. Learning from the lessons of the past, NWMO made significant efforts to address societal aspects of long-term nuclear fuel management. The study conducted by NWMO over a three-year period engaged 18,000 Canadians, including 2500 Aboriginal people, and received contributions from 500 experts, included 120 information and discussion sessions across all provinces and territories and contributions from a dedicated panel of ethicists. Not surprisingly, there was a wide diversity of views. A very common reaction from Canadians was "why did we create this waste without a well-defined plan?" There was, however, common ground on a number of points. Safety and security is top priority, this generation must take action now to manage waste we created and the approach must be consistent with and take advantage of international standards. Because of the long timeframes involved, the plan must be adaptable to allow for improvements in technology and changes in societal priorities.

5. ADAPTIVE PHASED MANAGEMENT

NWMO's recommendation for Adaptive Phased Management (APM) emerged from these dialogues as the approach that would best meet the priorities and values of Canadians and was submitted to the Government of Canada. APM is both a technical method and a management system. The technical method is isolation in a deep geological formation where spent fuel can be monitored and can be retrieved if necessary. Equally important is the management system that defines how to proceed. This is specifically tailored to values and priorities of Canadians. It requires flexibility in the pace and manner of implementation, openness, transparency, and staged decision making with the involvement of Canadians at every step of the way. It requires responsiveness to new developments and traditional Aboriginal knowledge and that the facility be located in an informed and willing host community. These management system requirements form the "social license" to proceed.

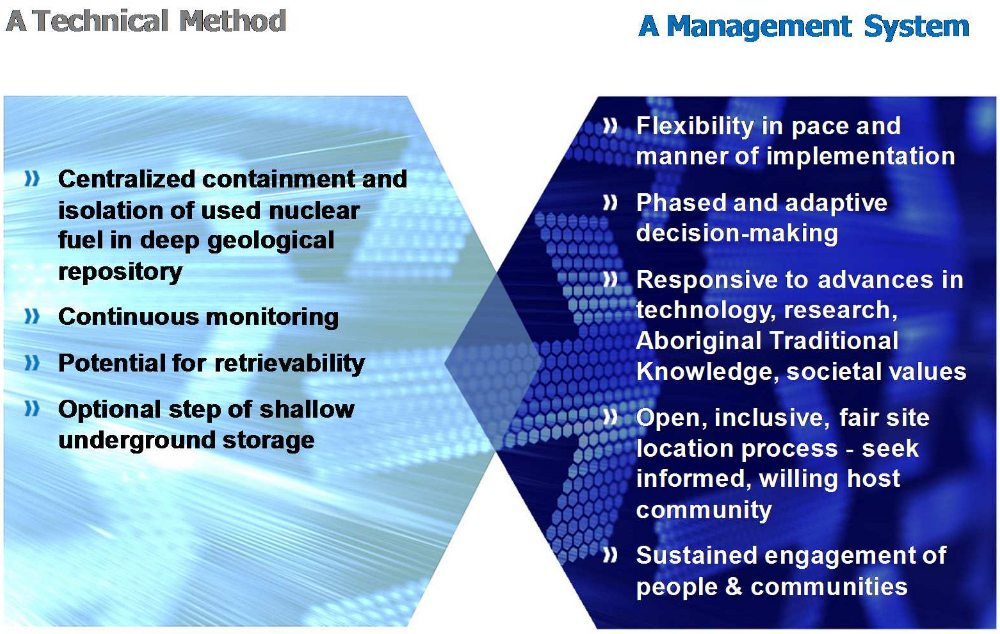

FIG. 2. NWMO adaptive phased management.

6. FEDERALLY MANDATED NATIONAL INFRASTRUCTURE PROJECT

The Government of Canada adopted APM as the national policy for spent fuel in June 2007. NWMO is now responsible for implementing what is considered to be a national infrastructure project. This will involve an investment of $16 B by the owners of spent fuel. It will be a high technology project with skilled employment over many decades and will operate as a centre of expertise for international collaboration. It will involve a long-term partnership between the NWMO and the host community, and will foster community well-being. It will be highly regulated and, with strict scientific and technical criteria, assure safety.

7. ADAPTIVE PHASED MANAGEMENT IMPLEMENTATION PLAN

In 2008, NWMO published an implementation plan for APM. This plan was published after two rounds of public consultation. The plan involves building long-term relationships with interested Canadians and involving them in decision making, refining and further developing repository design and safety cases, collaboratively defining and implementing a process for site selection, developing and refining a formula for trust funds for long-term financial surety to ensure that those that benefit from nuclear energy pay for the long-term cost, continuous research into alternative technical methods and societal expectations to ensure our plans adapt to changing circumstances, and a commitment to continually improve governance structures and organizational capability.

8. BUILDING RELATIONSHIPS AND INVOLVING CANADIANS IN DECISION MAKING

Building relationships and involving interested Canadians in decision making is critical to long-term success. NWMO is working on behalf of Canadians to implement APM and can only succeed by maintaining a social license to proceed. Several mechanisms have been established to achieve this objective in a systematic way. This includes a forum of Aboriginal Elders from across Canada and an Aboriginal Working Group, projects with several Aboriginal groups, including the Assembly of First Nations, a forum of Municipal Associations, and frequent dialogues with reactor communities through the Canadian Association of Nuclear Host Municipalities. It also includes a network of Citizen Panels representing a cross-section of socially active Canadians, multi-party dialogues where we bring together interested parties such as industry, Aboriginal people, special interest groups, and multi-department meetings with Provincial Governments and Federal Government departments. These mechanisms are used on a frequent basis to seek input to implementation plans and, more recently, plans on site selection.

9. REPOSITORY DESIGN AND SAFETY CASE REFINEMENT AND DEVELOPMENT

The second part of the plan is to further refine and develop the design and safety case for repositories in both crystalline and sedimentary rock formation. When developed, these will be subjected to pre-licensing regulatory reviews by our regulator, the Canadian Nuclear Safety Commission, within the next two years. This work will further shape our ongoing program of development and confidence building. There is a high degree of international collaboration in this area. NWMO has established exchange agreements with our sister organizations in Switzerland, Finland, Sweden and France. NWMO is also engaged in several joint development projects with international partners and by development projects in 11 Canadian universities. NWMO's Board of Directors has also established an International Technical Review Group made up of experts from four countries to annually review our work. Their report, like all of NWMO's work, is posted on the NWMO website.

10. COLLABORATIVE DESIGN OF PROCESS FOR SITE SELECTION

The third, and probably the most challenging part of our implementation plan, is the process of site selection. During the course of 2008 and 2009, NWMO held a number of rounds of public dialogues in four provinces, using the mechanisms described above. The first dialogues focused on the principles that should apply to site selection. We then translated what we heard in these dialogues into a draft site selection process document. In summary, the site selection document contains:

- Project description;
- A nine-step process of social, safety and environmental evaluation and evaluation criteria;
- It embodies the concept that a community chooses to participate and has the right to withdraw;
- It commits to a partnership approach and it provides for the inclusion of surrounding communities and Aboriginal people;
- It defines the role of independent third-party reviews and outlines the regulatory review steps.

This draft document was published in 2009 and subjected to a second series of extensive dialogues. This second round of dialogues generated sufficient consensus to give us confidence to initiate the site selection process.

11. WHAT WE HAVE HEARD ABOUT THE DRAFT SITING SELECTION PROCESS

We heard a number of reoccurring themes during our discussions on the draft processes.

- Safety, security, environment;
- Visible presence of federal government;
- Early and active role for regulator;
- Supportive role of provincial governments;
- Community benefits;
- Importance of community-based process with Aboriginal communities;
- Recognition of Aboriginal and treaty rights and duty to consult and accommodate.

The results of the two-year dialogues on the process for site selection have now been built into the revised document.

12. NEXT STEPS

On May 25, the site selection process was initiated by posting the final document on the NWMO website and by a mail-out to interested individuals and organizations. In the 2010–2011 time period, NWMO expects to focus on building awareness and responding to interested individuals, organizations and communities. NWMO intends to slowly build awareness through Municipal and Aboriginal conferences attended by community leaders. A “Learn More” program will be initiated to guide how NWMO will help individual organizations and communities learn more. Where communities step forward with an interest, NWMO will initiate initial technical and social economic assessment in collaboration with communities and potentially at a regional level. In later years, possibly 2012 through 2018, NWMO expects to initiate detailed feasibility studies. Progress is anticipated to be in stages through regional studies of social, economic, cultural effects with the involvement of surrounding regional communities, provincial governments and Aboriginal governments. This will occur in parallel to detailed technical site evaluations. Finally a community expresses willingness to host. Within the next seven to ten years, NWMO may be in a position to enter into an agreement with a single community and to initiate the regulatory review process. The earliest date that a DGR could be in service is 2035. All of these timelines are subject to change. As society's views and priorities develop, so must the processes and plans adapt. NWMO has a strongly stated commitment to take the time necessary to do this well.

13. SUMMARY

Spent nuclear fuel is currently safely stored at reactor sites and there is no urgent safety or environmental impact reason to change this. Canada has been working on long-term management of spent fuel for 30 years and, together with our international partners, the technology for the safe long-term isolation in a geologic formation is in place. Trust funds and mechanisms are in place to ensure that financial burdens will not be passed on to future generations. Twenty-five years ago a moratorium was placed on siting a repository. As a result of successive reviews, extensive dialogue and a government decision, NWMO now has a mandate to proceed. That mandate is consistent with the expectations of Canadians who would like to see action taken on long-term plans.