Making the Case for Integrated Nuclear Waste Management in the United States: Issues and Options

Charles W. Powers and David S. Kosson
Consortium for Risk Evaluation with Stakeholder Participation (CRESP), and
Department of Civil and Environmental Engineering
Vanderbilt University
Nashville, Tennessee[1]

Abstract
The United States has a unique national opportunity with respect to nuclear waste management because of confluence of needs for energy security, for mitigation of climate change, for disposition of defense-related legacy nuclear materials and wastes, national security factors and improved protection of human health and the environment from radiological hazards. However, the federal government has failed to make a convincing case to multiple constituencies that an integrated nuclear waste management system is both an essential national need and that such a system can be implemented in a credible, safe publicly accepted and sustainable manner. This paper identifies important components for achieving an "integrated system." Focus is placed on potential approaches to unlocking the current roadblocks to effective and efficient management of used nuclear fuel and high level waste from defense and civilian origins because public confidence in management of these materials is so central to the future role of nuclear energy as part of a national strategy to reducing greenhouse gas emissions and achieving energy security. Key to success will be effectively implementing the principles of safety, informed consent and equity.

[1] This report is based on work supported by the U. S. Department of Energy, under Cooperative Agreement Number DE-FC01-06EW07053 entitled 'The Consortium for Risk Evaluation with Stakeholder Participation III' awarded to Vanderbilt University. The opinions, findings, conclusions, or recommendations expressed herein are those of the authors and do not necessarily represent the views of the Department of Energy or Vanderbilt University.

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Introduction

An integrated nuclear waste management strategy is essential for the future expansion of nuclear energy, enabling energy security and reducing greenhouse gas and other detrimental emissions as part of an overall energy policy, and for managing the legacy of nuclear materials production for defense purposes. In addition, the disposal of radioactive waste from medical and industrial uses is reaching crisis proportion because of limited and declining licensed disposal capacity. The analysis provided here is based largely on symposia and workshops held at Vanderbilt with leading experts over the past year[2], and a comprehensive review of the history and legal aspects of nuclear waste management carried out by R. Stewart and J. Stewart as part of CRESP[3].

The federal agencies associated with nuclear waste management have been "prevented" by statute from engaging in a robust analysis of alternative ways of "managing" key nuclear residuals and materials. Hence the basic nuclear residuals strategy the nation has pursued for three decades is a controversial "nuclear waste management strategy" focused almost entirely on a specific approach to a subset of those residual materials that was set in motion by judgments, processes and events that occurred in 1977-8. The actual statutory deterrent to re-examining this strategy came in the Nuclear Waste Policy Act (1982) and was made more explicit in the major amendment to that law (1987) when congress stipulated that high level waste and civilian spent nuclear fuel were to be permanently placed in a federal geologic repository at Yucca Mountain in Nevada, and that the Department should not consider alternative approaches until that repository had been constructed. Despite active opposition by Nevada to all aspects of that siting process, both congress and the president have consistently taken steps to reaffirm that strategy and the Department of Energy has for two decades pursued it aggressively, currently as part of the DOE Office of Civilian Radioactive Waste Management. In June 2008 – ten years after the statute called for repository to have been opened - DOE submitted to the Nuclear Regulatory Commission, and the Commission has docketed, an application for a license to construct that facility. Informal discussion of alternative approaches has, of course, continued. And activities not covered by the Nuclear Waste Policy Act, notably development and operation of Waste Integration Pilot Plant (WIPP) in New Mexico (the world's first deep geologic repository for nuclear waste), have quietly and successfully occurred under the DOE Office of Environmental Management. Still, it was not until the energy appropriations bills for fiscal years 2006 and 2007 that Congress opened a statutory path to activities and analyses that would clearly allow alternative strategies to the paradigm developed in the 1980's to be actively considered[4]. Now that the Yucca Mountain license application is under review, it is time to put the prospects of this geologic repository into the broader context of what are the several sets of activities that would yield a robust system in a timeframe that addresses the country's timetable for energy independence.

The United States stands at a critical juncture with respect to how it both produces and uses the energy it needs to function. There is unprecedented agreement among all political actors and parties – and apparently the vast majority of the American people – that **within a decade**, the United States should be on a course to becoming energy independent. Most also agree with another premise: reducing the rate of climate change requires that the sources and uses of energy must reduce the rate of production of greenhouse gases, especially carbon dioxide ("carbon

[2] See *"The Back-end: Healing the Achilles Heel of the Nuclear Renaissance?" March 3, 2008*. Vanderbilt University, Nashville, TN, and *Uncertainty in Long Term Planning-Nuclear Waste Management, a Case Study*. January 7-8. Vanderbilt University, Nashville, TN at http://www.cresp.org.

[3] R. Stewart and J. Stewart. United States Nuclear Waste Regulatory Law and Policy, CRESP III report, 2008 (draft).

[4] U.S. House Committee on Appropriations, Report to accompany Energy and Water Development Bill, 2007 [H.R. 5427], 109th Cong., 2d sess., 2006, Rept. 109-474. U.S House Committee on Appropriations, Report to accompany Energy and Water Development Bill, 2009. Draft Committee Report released July 2008.

footprint"). The truly new factor in this equation is the national and international sense of urgency: real solutions must be both identified and implemented in a decade. Politically, that means that the key policy decisions about what are the solutions should be reached before the end of the next presidential term (2012) and implementation of those decisions should be in the field and well advanced by the end of the succeeding term (2016) to provide the nation with confidence that this issue is on the way to substantial resolution. However, the set of solutions selected will invariably require evolutionary, not revolutionary, change to account for existing infrastructure, techno logical advances, and investment cycles.

There is far less political or public agreement that nuclear energy should play an important role in that energy transformation - let alone that it is a primary component of a solution that must include balanced emphasis on improved efficiency in energy utilization and increased reliance on renewable energy sources such as wind and solar. Nuclear's minimal carbon footprint is now well understood. But the major uncertainty about nuclear energy revolves around the word "safe". Can nuclear power - the processes that produce it and the residuals it generates – be managed safely? Concern about nuclear power's safety has paralyzed new plant development for 30 years; and the current predominant concern about nuclear safety is focused on establishing a clear and acceptable path to long-term safe management of nuclear waste, including where and when it can be done. Either the nation will have developed confidence that *in the next decade* it will have secured a path forward for the safe, effective, integrated short and long-term management of current and future nuclear waste, or nuclear power is unlikely to play a significant long-term role in the nation's energy future.

The fundamental challenge to the analysis we undertake here is to demonstrate that paths to the most troublesome facets of secure nuclear waste management can be found. Such paths will be more attractive if they simultaneously stimulate the search for nuclear answers that will, in the future, improve efficiency of nuclear technologies and reduce the amount of needed waste disposal capacity. The time has come to show the nation that, if it chooses an accelerated nuclear energy option, it can and will have the key elements of a safe and accepted nuclear waste path marked out, and that the key facilities needed at each stage along the way will be ready as the system is actually implemented. Given the emerging consensus that energy solutions are needed "now", a well marked system must be charted and underway within two presidential terms. Although the systems that classify and regulate waste management of nuclear residuals are all complex and challenging, it is the materials that are required to go to deep geologic repositories that are, deservedly, the primary focus of public concern.

There are two fundamentally distinct types of materials that are currently destined for a high level waste geologic repositories: vitrified high level waste in canisters that has originated from the processes used to recover usable defense related constituents or recycle nuclear fuel (described as HLW), and spent nuclear fuel itself (described as SNF). Much, but not all, of repository bound defense nuclear waste is HLW – but some defense fuel rods were not reprocessed and so there is a significant amount of defense SNF. Almost all civilian waste mandated to go to repositories is SNF – but there is some vitrified HLW resulting from efforts at one facility (West Valley) to recycle civilian fuel rods – and were civilian nuclear fuel to be recycled in the future, the resulting predominant waste would be considered HLW under current classification and be analogous to vitrified HLW produced from current defense wastes. To further complicate the discussion, there are or have been transuranic wastes (TRU) at most defense facilities that are required to go to a deep geologic repository (WIPP). Of course there are other materials that were never actually part of the fuel cycle that are classified based on radioactive constituents and their concentrations rather than their origin (low-level waste, LLW) and others that contain both radioactive waste characteristics and hazardous (non-radioactive) wastes , termed "mixed" wastes. The reason to review these differences here is that the way that the law currently directs materials to deep geologic repositories is not consistently related to how long the type and persistence of the hazards and risks posed by the materials, or the ways in which they need to be shielded from the public, and surely not whether they are were generated by defense or civilian activities. That means that the question of how the system ought to be organized to achieve sustainable protection of human health and the environment for nuclear wastes with different physical, chemical and radionuclide characteristics (hazards) and potential scenarios to impact human health and the environment (risks) does not flow naturally from the current waste classification system. Revising the classification system to be more directly based on hazards and risks would help future management by providing a more systematic and transparent approach; however, the option to grandfather existing wastes under the current system is essential to provide for an orderly transition to new classifications.

Since it is widely acknowledged that some aspects of the nation's laws regarding nuclear waste management are going to need amendment, in this discussion we are going to "think outside" the current legal structure. The purpose of this paper is to consider a set of options that will open the way for the safe integrated management of nuclear wastes that have and will result from both civilian and national security-related use of key nuclear materials.

The Three Questions

Three questions must be adequately answered to make the case for an integrated nuclear waste management system:

1. *Why do we need a complete system for nuclear waste management (including geologic repositories)?*

   If we had such a system, it would:

   - Address one of the major real and perceived obstacles to obtaining the benefits of nuclear energy (at current or increased levels) for energy security as part of the national energy portfolio that includes conservation, renewable and reduced reliance on fossil fuels;
   - Facilitate achieving acceptable environmental protection, integral to the utilization of nuclear energy as a source of energy, by: 1) avoiding emissions of greenhouse gases and other emissions (e.g., mercury, arsenic, particulates, oxides of nitrogen); 2) providing for the responsible management of used nuclear fuel and wastes through full life cycle management; 3) providing protective care that, taken together, exceeds the protections provided other energy options from adverse environmental and human health effects.
   - Materially advances national security by providing models and actual direct involvement in the future of nuclear processes when many nations have clearly chosen expansion of nuclear power. As a result, U.S. engagement and leadership to prevent weapons proliferation and achieve international protective management of wastes will be bolstered
   - Facilitate more rapid and cost effective remediation of nuclear materials and wastes from defense activities currently in storage at multiple locations across the country.

2. *What criteria would a complete system have to meet in order to provide safety and responsibility, considering current and future knowledge and uncertainties?*

   Essential criteria would include that the implemented system:

   - Is consistent with the best technical evaluation based on current knowledge and that pilot demonstration and evaluation of the system provides confidence in that technical evaluation.
   - Provides multiple, redundant protective systems through engineered barriers and natural systems adequate to address the materials/wastes to be managed at the facilities needed in each option.
   - Incorporates a process of continuous learning through on-going, full term testing of system components and integrated systems with feedback mechanisms to test the performance evaluation, design and operations as well as other knowledge - including evolved understanding - of factors as diverse as enabling use of proven new technologies to achieve more effective nuclear resource utilization and evolved understanding of human health effects (medical, etc).

- Incorporates pre-emptive monitoring in-place and designed to facilitate detection and correction needed to respond to unforeseen processes and events.
- Provides for retrievability of nuclear materials/wastes for many generations to come to allow review and changes based on future resource needs, knowledge and values.
- Provides for technically safe permanent disposal if future generations chose that option without placing unreasonable financial burdens on future generations.
- Is developed and maintained by stable and credible institutions to ensure management consistent with these criteria over the full-term of its operation.

3. *When is it in a community's, state's and the national interest to host nuclear materials and waste management facilities?*

   A community and state should elect to host one or more nuclear materials and waste management facilities when the facility:

   - Is selected as part of a fair site selection process and through credible regulatory processes.
   - The host community is fully familiar with the nuclear energy and or nuclear systems to be operated (informed) and knowledgeably agrees to their local siting and operation throughout the process of the facility development (consent).
   - The affected parties and communities (including at local and state levels) are all part of an equitable distribution of the benefits of the facility.
   - The affected parties and communities are assured of a long-term commitment to diverse and evolving patterns of economic support and development that is responsive to the community's needs (infrastructure, educational opportunity), in addition to direct benefits (jobs, property subsidies, etc.), that is synergistic with the facility's mission.
   - Provides equity at a national level to those regions that both benefit from nuclear energy and accept responsibility for managing used fuel and wastes.

As discussed earlier, our goal is to combine in our analysis two factors that appear to have gotten lost in the debate about Yucca Mountain. Those factors are equity and informed consent – but always in the context of the obligation to meet conditions of safety. We are attempting to sort out how those factors could actually be combined in the selection of any new nuclear facility – and that means that the fundamental challenge is to determine "what it would take" to get a community and its neighboring "affected constituencies" (particularly the state in which the community is located) to accept a nuclear waste facility. Adequate understanding and engagement of state officials is particularly important.

While the three central questions are identified above and a synopsis of the rationale for answering each of these questions is provided, not all of the processes and systems are in place to provide the complete supporting basis for addressing each question. The federal government (Congress, DOE, NRC and others) and the nuclear industry should be responsible for providing a coordinated, consistent and well founded administrative, technical, stakeholder involvement, and education system that allows affirmative responses to each question.

Past Choices and Evolving Ethical Perspectives

In 1977 and 1978 the nation made a series of fundamental choices about the principles of nuclear waste policy that for the ensuing 30 years have effectively determined all federal actions related to the storage and disposition of most of the nation's nuclear materials.

There were four basic choices that became a set of premises of almost all nuclear waste management action: 1) the nation would no longer recycle its used, but energy-rich, used (spent) nuclear fuel because, it was believed, that recycling process would promote proliferation of nuclear weapons; 2) management of used fuel would be restricted to burying it permanently and safely in deep geologic repositories – immediately - so that the burden of its management would not be passed on to future generations; and 3) the selection of the specific characteristics and location(s) of the repository(ies) would be based on technical factors and regional equity, not local public acceptance, since, it was believed, no community or state would ever voluntarily support the nearby siting of such facilities ("Not in my back yard"); 4) efficiency dictates that a single repository should host both the civilian and defense wastes, including both spent nuclear fuel and vitrified high level waste, that are to be sent to a geological repository.

A strong case can be made for a second totally different set of premises. In the intervening three decades the context for energy choice has been transformed by both 1) the dramatic increase in the nation's dependence on foreign sources (with stark economic and national security implications) and 2) the evolving recognition that world-wide patterns of energy use had caused and would continue to cause global warming and its adverse effects. Hence, in retrospect, alternative premises might have been both implementable and have better served the diverse public purposes that have emerged early in the 21st century. Those "alternative premises" can be simply stated: 1) If it can be done safely, economically and protect against proliferation, the nation should develop the capacity to retrieve the energy left in nuclear fuel after initial use; 2) this fuel should be stored for a significant period of time (at least 90 years) in intermediate surface storage facilities, both so that it "cools" and thus can be more efficiently stored permanently and be available should effective recycling technologies and systems evolve; 3) when good practices are employed in nuclear residuals management (whether in its transportation, storage, or permanent disposition) the risks are not greater than the risks from management of other hazardous materials; 4) nuclear materials management should take place in locations where the affected communities understand and want to host the nuclear facilities, when adequate financial and safety considerations are made ("Yes in my backyard"); and, 5) the decisions about how many geologic repositories are needed and whether both defense and civilian wastes (or spent nuclear fuel and vitrified high level waste) should be sent to the same repository are not premises, but should be evolving conclusions or inferences based on both the characteristics of developing waste form characteristics and more mature estimates as to what repository capacity is needed - in specific timeframes -over the long-term.

Underlying the two sets of premises described above are a series of policy judgments that, interestingly, both seek to accommodate the same two ethical principles of fairness[5] and informed consent, although in radically different ways. The two sets of premises assume different empirical judgments about the inherent dangers posed by SNF and HLW, and therefore they result in different conclusions about who is responsible for what forms of waste management and when.

Fairness for the framers of the first set of premises was focused on inter-generational equity; informed consent meant the next generation should not have to bear burdens from a prior generation's decisions. Together this formulation of the ethical requirements led directly to a conclusion about who was responsible for completely addressing the nuclear waste generated, i.e.: *the generation of citizens which has enjoyed the benefits of nuclear energy has an obligation to responsibly dispose the waste.* But what did such disposal involve, including when and

[5] Colglazier (2008) identified three types of individual and society values that determine the "fairness" of a nuclear waste management system and associated facilities. The first was procedural values that determine the fairness of the decision process. The second was distributional values, which determine the fair allocation of costs, benefits and risks to stakeholders and society as a whole. The third was evidential values, which determines the standard of evidence necessary to make specific decisions given inherent, and often irreducible, uncertainty. In short, "how sure is sure enough?" Colglazier further draws analogy to current concerns about global climate change – society needs to decide on actions for societal benefit in the face of uncertainty. Colglazier, E.W. 2008. Stewardship and Nuclear Waste: What is Our Responsibility to Future Generations? *Symposium and Celebration In Honor of Frank L. Parker, Uncertainty in Long Term Planning-Nuclear Waste Management, a Case Study*, March 3, 2008. Vanderbilt University, Nashville, TN at http://www.cresp.org.

for how long? Having decided at that time that reuse of the used fuel from reactors would create materials that posed unacceptable risks of proliferation, and accepting the scientific consensus that the fuel should be placed in a deep geologic repository, the 1978 decision was inevitable: the fuel rods should be located in a deep geologic repository where they could be secure *in-perpetuity*. However, because the fairness issue was entirely focused on which generation should make the decision and bear the burden, the issue of who in the current generation should fairly bear the burden of having the waste nearby was secondary to the technical issue of finding the most secure final resting place for what decision-makers then clearly saw as horrific and dangerous wastes.[6] Furthermore, the issue of equitable compensation for hosting such a facility was not addressed.

It may rightly be said that fairness and informed consent in this first set of premises could just as well be focused on who in the current generation should bear the burden, rather than on which generation should do so. Nevada has made that case in innumerable ways and times: 1) fairness? "Not us" because Nevadans were not, in fact, the real beneficiaries (not only is there no proportional fairness, but selection of Yucca represents the imposition of the burden on those in this nation who derive no or few benefits from nuclear power - "we have no reactors here"); 2) informed consent? "Not us" because as a state we have, ever since you exclusively designated us refused to consent to Yucca, and ever more so as we are better informed about it"; and, 3) "Not us", because the federal government's choice of Yucca violated its own commitment to choose on the basis of technical comparison - since the federal government never proved that Yucca was the most secure repository setting ("you stopped looking at the alternatives before that technical judgment could ever be made").

The second set of premises described above fundamentally alters the landscape in which these fairness and informed consent issues are employed because it changes the timeframes within which key factual judgments will be made. Do we know yet what materials we want or need to permanently place in a repository. If the issue of reactor fuel reuse is still to be decided, do we know yet what is the necessary disposal context for the materials that ultimately need to go to a repository? And might the nature of the materials require different permanent disposal contexts? Do nuclear residuals actually pose unique risks when we consider both the hazard and likelihood of harm under the proposed management scenario? And should the answer be shaped by the fact that many of those wastes over time actually transform themselves to inert materials and, in addition, are immobilized within relatively stable matrices (i.e., glass)? Should the current generation preclude a decision by future generations to safely utilize the remaining energy potential in the used fuel? If decisions on these key empirical elements should be delayed until we know more, then how might the major ethical principles be arrayed differently to better inform who is responsible for what and when?

The imperative felt in the last two decades of the 20th century to decide where the repository should go, and when and what should go there, was driven by the concern that one's own generation's rationalizations should not divert our attention from fulfilling its responsibility to future generations.[7] However, we also do not want to "impose" on

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[6] In the congressional political battles that ensued, the technical search was, by 1987 and by law, called off and the selected site was imposed on Nevada. The conclusion that the nation might try to wriggle off the commitment to build a deep geologic repository was five years later addressed by allowing no other significant waste management facility to be explored until the repository at Yucca was constructed. However, this approach also has facilitated a perception that Yucca will become the only geologic repository for such materials (through statutory redefinition of the allowable disposal capacity).

[7] Russell draws the conclusion that our sense of moral obligations derives from our sense of connectedness with the people impacted by our actions and therefore distance in time and location should have similar consideration in our decisions: *our connection to 10 or 100 generations in the future is more remote than our sense of obligation to distant world events with which we do not engage. Therefore, our judgments of prudent use of current resources should be a balanced reflection of our values and immediate generations because many generations in the future will likely derive little benefit and have different norms and values".* Russell, M. (2008) Long and Long Long-term Management: Goals and Criteria" at a Workshop, *Uncertainty in Long Term Planning-Nuclear Waste Management, a Case Study*. January 7-8, 2008. Vanderbilt University, Nashville, TN.

the next generation the loss of nuclear residuals they may later see as resources they wish to use. What emerges then is the challenge of finding waste management resolutions that achieve both 1) allowing each next generation freedom to choose what to do with what "the prior generation" left behind and 2) not having to face the unfairness of especially heavy financial burdens that some of our own choices may impose. The reconciliation of these factors might be achieved by taking the steps to evaluate and actually prepare the final disposition locations but yet not actually permanently disposing of the materials (the concept of "retrievability" planned but undemonstrated for the pre-closure stage of Yucca Mountain). That is precisely what Canada has recently decided: *Our obligation is to give them (the succeeding generation) a real choice and the opportunity to shape their own decisions while at the same time not imposing a burden which future generations may not be able to manage.* As a result, Canada has selected a process it describes as phased adaptive management for making its nuclear waste decisions.[8]

Does the alternative approach suggested by the second set of premises help establish a basis for resolving the "intra-generational" nuclear waste battle the nation currently faces? That depends on whether both fairness and informed consent can be jointly addressed and whether the timeframes for location and waste type decisions track with an evolving public understanding of what would be beneficial for safety and security of the wastes. From both a safety and security perspective, it is preferable to move used nuclear fuel from the current storage at more than 100 sites after the initial radioactive decay. Cooling and preparation of used nuclear fuel allows safe geographic consolidation, to more centralized locations where it can be more securely and efficiently managed. Equity concerns suggest that the consolidation locations be in the "regions" where the benefits of nuclear power [electricity production] are being distributed. *Informed* consent requires that the selected locations be places where "consent" to the activities and storage is achieved only when the safety case is well understood and accepted as protective, and adequate proportional compensation is provided. How long should the used nuclear fuel stay at the regional intermediate storage locations? Technical issues related to optimal decay time (to reduce thermal and shielding burdens), demonstration (pilot-scale evaluation) of the performance assumptions of the repository systems, and proximity to reprocessing pilot testing provide additional location and timeframe determinants that could further inform the decision basis.

If the above approach has begun to prove successful as applied to interim storage, a new start toward wedding technical factors, fairness and informed consent efforts could be made in respect to repository selection and development as well. The nation already has – but rarely acknowledges - the application of many of these concepts in the successful definition and implementation of WIPP, a fully functioning radioactive materials deep geologic repository that has been and continues to evolve as a "pilot plant", with the informed consent of the local community. The processes used to achieve public support for the evolution of WIPP as a repository might become, in part, guidance for a new effort to achieve system-wide repository definition and evolution. The concept that the full integrated system of nuclear waste management facilities – from DOE site or generator site (cradle) to final disposition (grave) – is to be evolved with the twin commitments to meet both inter-generation and intra-generational responsibilities fairly and with informed consent of the affected parties, could transform every current perception about the nation's management of nuclear waste.

Essential Elements of an Effective and Credible System

The success of an integrated nuclear materials and waste management system will depend on being widely understood as a critical component of the nation's energy policy, being recognized as responsible protection of human health and the environment, and having credibility as an effectively managed and technically sound institution. Furthermore, the process to achieve the needed system must be responsive to an ever evolving set of societal values (as discussed above) and responsive to new knowledge. The following sections present essential

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[8] Nuclear Waste Management Organization (Canada), Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel, 2005.

elements of an effective and credible nuclear waste management system, without which public confidence is eroded and the challenge of providing the needed system is magnified.

National Energy Policy

Pacala and Socolow[9] effectively made the case that addressing the global climate change challenge in the face of growing energy demand will require a portfolio of approaches for improved energy efficiency and energy production. Nuclear energy is becoming widely recognized as an important part of the portfolio, but the United States fails to have a national energy policy that sets meaningful target ranges[10] for the nation's portfolio with credible allocation of resources to achieve the desired balance. Nuclear energy should be part of the portfolio along with conservation and multiple energy sources. Absent a clearly articulated energy policy, including a balanced energy portfolio with specific goals and a federal investment strategy, nuclear waste management becomes the focus for inhibiting progress in an "either/or" debate, rather than achieving a solution in the national interest. Nuclear waste management is part of the essential components of nuclear energy, along with safety, security and cost. Nuclear energy provides the benefits of minimal greenhouse gas emissions, reduced emissions of potentially harmful constituents, relatively small quantities of waste to be managed and domestically available natural resources. Further benefits include maintaining an internationally competitive technology base that facilitates a clear voice in international arenas regarding nuclear energy development by other countries to prevent nuclear weapons proliferation. Such approaches have already been a cornerstone of "fuel lease programs" supported by the United States.

Institutional Requirements

An effective waste management system requires organizational stability, including focused long-term leadership that is respected by the full range of constituencies and the technical community, and sufficient professional staff emphasizing technical competence and excellence in all facets of responsibilities. The current Department of Energy structure encourages frequent leadership turnover through the political appointment process, with typical leadership terms from 18 to 36 months. This results in frequent programmatic redirection and detracts from staff continuity. Alternatively, this should be viewed as a long-term national need, with a reward structure that encourages excellence in performance, continuous learning throughout the program, and continuity of interaction between the program management and the diverse program constituencies. Credibility of the program leadership and continuity of interactions with local and national communities is one programmatic aspect that has been credited with success for other international programs.[11]

A second institutional requirement is sufficient and stable programmatic financial support that is independent of political manipulation. Although a tax on nuclear energy production designated specifically for nuclear waste management has resulted in a twenty-six billion dollar Nuclear Waste Fund, program funding management of

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[9] Pacala, S., & R. Socolow. (2004). Stabilization Wedges: Solving the Climate Problem for the Next 50 Years with Current Technologies. *Science, 305*, 968-972.

[10] Ranges, not specific point values, are needed to facilitate adaptation in response to market forces.

[11] Thegerstrom, C. (2008). Progress in Implementation of a System for Deep Geological Disposal of Spent Nuclear Fuel in Sweden – Technical and Social Aspects, *A presentation to the Symposium and Celebration In Honor of Frank L. Parker, Uncertainty in Long Term Planning-Nuclear Waste Management, a Case Study*. January 7-8. Vanderbilt University, Nashville, TN at http://www.cresp.org. Also Marivoet, J. (2008). Impact of Advanced Fuel Cycles on Geological Disposal in a Clay Formation, *A Presentation to the Nuclear Integration Project (NIP) Workshop: "The Back-end: Healing the Achilles Heel of the Nuclear Renaissance?" March 3, 2008*. Vanderbilt University, Nashville, TN at http://www.cresp.org.

civilian SNF is dependent on annual congressional appropriations, while the accrued energy tax revenue is considered part of the federal general fund to offset national budget deficits[12].

The combined needs for stable program leadership, staff and financial support suggest that alternative organizational structures warrant consideration. The waste management facility siting process (for all new facilities, either for storage or disposal) may be best handled by an independent federal commission of limited size (e.g., 3-5) with membership from diverse backgrounds, including but not limited to technical expertise, and with unassailable reputations. After preliminary site selection, site investigations and operations may be best handled by a federal corporation (analogous to the Tennessee Valley Authority). However, we consider that addressing such a critical national need combined with the intense public concern necessitates that the overall management system remains an inherently government function which should not be privatized. Independent oversight and review should also be incorporated into the institutional system mandate.

Protection of human health and the environment is an absolute requirement for all facilities. However, specific requirements should be risk and hazard-informed and emphasize system performance characteristics that can be validated over the operational life (pre-closure) of the facility and support adaptive management in response to new knowledge, such as recommended by the National Academies.[13] The relevant basis for assessing the technical suitability for facilities should include:

- Multiple lines of evidence to establish a safety case for long-term performance, including (i) consideration of engineered barriers, (ii) geologic barriers, systems and processes, and (iii) natural analogues.
- Probabilistic performance assessment as organizing and assessment tool that (i) includes range of cases and scenarios, (ii) uses the best current phenomenological understanding for processes which effect outcome, minimizing reliance on bounding estimates for critical processes, and (iii) addresses model, parameter and intrinsic uncertainty.
- On-going research to continuously learn, enhance operations and reduce uncertainty in the safety case.
- Emphasis on passive systems and combined contributions of engineered and natural systems.

Inherent in new institutional structures should be clear commitment to transparency, continuous learning, on-going stakeholder engagement, and education. Stakeholder engagement should be accomplished at multiple levels and through multiple approaches and incorporate evaluation of the engagement process and its impact on information transfer and trust.[14]

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[12] Sproat, W. (2008). Yucca Mountain: The Real World Implementation Challenges, *A presentation to the Symposium and Celebration In Honor of Frank L. Parker, Uncertainty in Long Term Planning-Nuclear Waste Management, a Case Study*. Vanderbilt University, Nashville, TN at http://www.cresp.org.

[13] National Research Council (U.S.). Committee on Principles and Operational Strategies for Staged Repository Systems. (2003). *One step at a time: the staged development of geologic repositories for high-level radioactive waste*. Washington, D.C.: National Academies Press.

[14] The following Canadian study and provides a useful starting point: Nuclear Waste Management Organization (Canada), Choosing a Way Forward – The Future Management of Canada's Used Nuclear Fuel, 2005. For more information on the Canadian nuclear waste processes see Nuclear Waste Management Organization (Canada). (2003). Annual report (pp. v.). Toronto: Nuclear Waste Management Organization (Canada). See also the report of surveys of the views of citizens living near nuclear facilities n facility Greenberg, M. (2008). Are Nuclear Facilities LULUs?, *A presentation to the Symposium and Celebration In Honor of Frank L. Parker, Uncertainty in Long Term Planning-Nuclear Waste Management, a Case Study*. January 7-8. Vanderbilt University, Nashville, TN at http://www.cresp.org.

A Sustained Commitment to Nuclear Education

A knowledgeable public is needed to reduce misperceptions and fears, maintain insightful public scrutiny and build public trust, of nuclear materials, processes and energy production. A highly trained workforce, at multiple levels, will be required for the nation to design, build, construct and operate new nuclear facilities, as well as remediate and close legacy facilities. Collaborative research and development between universities, national laboratories and the private sector will be required for the country to maintain relevance and leadership in nuclear energy and economy in safely managing legacy materials and facilities. These needs speak to a broader educational initiative beyond a resurgence in nuclear engineering education. A long-term commitment is needed to include an understanding of radiation and nuclear materials, processes and energy at all levels of education, from primary through post-graduate education. Improved public understanding should be one goal. Technical leadership in key areas such as nuclear environmental protection, nuclear chemical engineering, nuclear construction management, as well as nuclear engineering and health physics should be second educational goal focused on higher education.

The Current System and Process

We need to step back here and ask the question – what would it take to achieve basic public acceptance of a path we could now pursue to manage nuclear wastes. The nation has been on the same basic path for the past 25 years – and clearly has made very limited progress in achieving general public acceptance of its current plan. The nation generally perceives the "nuclear waste problem" to be one that either has not been or cannot be resolved. Whether that problem is really technical or is political makes little difference. Why?

Surely concern with nuclear waste is partly linked with the well documented set of issues coined "nuclear fear". The poorly understood and secretive process that yielded nuclear weapons used in the 1940's – and their fearsome proliferation in the East-West standoff that resulted in civilian nuclear civil defense drills in the 60's gave way in the 70's to some acceptance of nuclear power until the twins - a "near miss" at 3 Mile Island followed by the Chernobyl disaster - brought civilian nuclear facility development to a standstill. In the late 90's and in the early 21st century the concern has shifted back to weapons, since it is fear of nuclear materials in the hands of terrorists and the new efforts by "rogue" states to make weapons that stirs public concern.

But, in fact, almost none of this has anything to do with SNF management from civilian nuclear reactors – something that the public can link to no actual major environmental or human health threatening incident. Nuclear waste management itself is demonstrably associated with fewer deaths or injuries to people and the environment per unit of energy than coal-based energy production. Why is it perceived so differently? Is it simply a matter of education? Partly, perhaps, but not primarily – and we will return to the point.

From the little we can tell from the modest public survey work done, there is very little public understanding of what the "nuclear waste problem" actually is. There is awareness among many Americans over 55 that in the late 1970's, the executive branch concluded that nuclear waste posed a unique problem and required a unique and dramatic path for its resolution; Congress in 1982 and again in 1987 appeared to ratify that verdict. But today there is in fact little contemporary understanding of those specific policy conclusions – except the one that mandated that Nevada was to be the home of the nation's repository for what has been perceived as the most dangerous type of waste. We believe that the struggle of the federal government with the State of Nevada over Yucca has, in fact, become the "surrogate" – today serves as the "proxy" - for any substantial understanding, or need to understand, the actual nuclear waste problem. The public perceives a stand-off at Yucca and that stand-off almost defines the problem: the Nevadans do not want the repository in their back yard and they must have good reasons for their persistent, nearly militant opposition. The twin media reports about nuclear waste which the public has received for the past decade are announcements that the federal government is taking some additional step toward Yucca completion (successful or thwarted) and that the State of Nevada has retaliated with some new action (successful or thwarted) to block Yucca.

What the public is told is that the concerted Nevada opposition has stopped the federal government to-date (Yucca is a decade late) and that Nevada is reported poised to continue do so; the federal government has tried to impose the repository on what was at the time the weakest state because no one else would take it and there must have been good reasons for that as well. Everything else about nuclear waste management is small print and consistent: 1) Whatever happened at the nation's weapons facilities to create their waste problems that continue to cost the nation billions of dollars yearly and that effort is always delayed, too; 2) Local communities remain troubled about the used fuel in their reactor's waste pools with no place to go; any new reactor means more such stagnant waste pools; 3) other countries, too, seem to have trouble deciding what to do with their wastes – don't they? Consequently, why should the public not conclude that nuclear waste in whatever form it comes, must have characteristics that make it especially unsafe and unmanageable. And, now to come full circle, significant reliance on increased use of nuclear power should await resolution of the [intractable] nuclear waste problem – whatever that means and don't expect that to happen.

And a nation now persuaded that the triad of issues well-known as "climate change, energy pricing and a national security policy hobbled by the nation's energy dependence" is ready to take decisive action now – in policy, investment and personal behavior – to do something about both energy supply and demand.

And what does the nation's current nuclear waste law and policy offer the action-ready and solution-thirsty public and its leadership? Stay the course with Yucca.

The clear inference is that the nation and its legislators should watch and wait because the federal government has just now applied to its regulator for a license to start building Yucca which, if accepted in three years, would allow construction of a facility in 12 years - that if ready today could not take all the waste it is mandated to take and could not have accepted much of the currently waiting waste for 35 years, or until after the middle of the century. It provides no clear answer to how to handle the additional waste we are currently generating – and the additional waste that would be generated if we switch toward greater reliance on nuclear energy. Some suggest that we should make Yucca even bigger at a cost of about $96 billion (a figure that has just this year increased by 35%). And all this assumes that a Nevada, more implacably opposed to this facility than ever before, not only does not succeed in slowing or freezing the process but issues permits to allow the facility land and water to operate. The nuclear waste problem is the Yucca problem – and whatever useful role Yucca may yet play in helping resolve it (and we believe it could be significant), the resolution of the nuclear waste challenge is unlikely to emerge from what is essentially a "wait and watch the Yucca drama" course of action.

What are the key elements of the options that may more clearly lead to an effective and credible integrated nuclear waste management system? Importantly, what can be done in the near-term (4 to 8 years) as steps to a long-term system that achieves the desired goals? We start by summarizing the current system, recognizing the present unique point in time following submission of a license application for Yucca Mountain and anticipating a 5-10 year review process and challenges that may lead to a licensed geologic repository for used nuclear fuel and vitrified high level waste, but still will have many challenges to achieving planned operations. We then explore limited variations on the currently planned system that may benefit implementation.

Alternative Options for a Path towards achieving a Credible and Effective System

In our view, the fact that Nevada is the focal point, the point of national paralysis and the surrogate or symbol for "the nuclear waste problem" – is instructive for guiding a new policy. We believe that the path and process to overcoming the Yucca stand-off is a careful review – and, more often than not, a change - of virtually every assumption that led to making Yucca the "silver bullet" for the nation's nuclear residuals management and the fundamental management decisions about its operation. And that will mean carefully framed changes in current law.

In the options we discuss below, the elements of an integrated strategy for nuclear materials management are "put together" very differently. But what they each have in common are the following factors that differ from the current national policy:

1. It is possible to site and manage the several types of nuclear residual materials as they decay over time with safer and less risky techniques than the current requirement that they be sent as soon as possible to a geologic repository – all without jeopardizing the appropriate national commitment to permanent geologic disposition of hazardous long-lived nuclear waste materials.

2. The review of the relative advantages of different types of repository environments (e.g., salt, granite, and clay) for permanent disposition of different types of nuclear materials that was halted 20 years ago should be renewed. This review will allow evolving understanding of these environments to help determine what materials should be sent to potentially different disposal systems when the final disposition is indicated. All repositories beginning with initial exploration of their viability should be defined as a pilot site whose evolution requires public approval at every key step in its implementation (as was and is WIPP - the only successful nuclear deep geologic facility in the world).

3. The siting of the several types of facilities needed for the management of nuclear residuals should be pursued by locating them so that principles of regional equity, of both burden and compensation for services provided, allow fundamental reconsideration by the affected public of the actual risks and rewards associated with the specific nuclear residuals management. The siting process should be carried out with the goal of placing facilities at sites (federal or private) approved with adequate stakeholder involvement and support.

4. The decision to place HLW and spent nuclear fuel (both defense and civilian) in the same repository may or may not optimize the fact that civilian and defense residuals and wastes can and will be prepared for final disposition in different ways. The alternatives of whether stabilized (i.e., vitrified) high level waste and spent nuclear fuel, as well as whether defense and civilian nuclear wastes should be combined or separated (at final disposition and at intermediate management/storage phases) should be reflected in the integrated system alternatives considered.

5. Transfer of nuclear materials to specific sites should achieve the consolidation of those materials consistent with safe and efficient management of them – in timeframes that most effectively reduce the risk of both the transfer and storage of the materials

6. The decision as to whether nuclear materials (specifically used fuel rods) should be directly disposed or should be reprocessed for re-use – is not one that should either be made or precluded in the options for an integrated nuclear management system at this time. The evolution of the reprocessing alternatives and capability, the implications for new waste generated, and the implications for advanced reactors linked to reprocessing alternatives can and should evolve on an independent track from the integrated waste system. However, the integrated waste system should be flexible enough to accommodate decisions resulting from further evaluation of reprocessing. Nevertheless, the implications for reduced nuclear waste disposition capacity that may result from re-use provides a compelling rationale for two other elements of policy: 1) determinations as to the size of repository need should be phased and not presumed; 2) the advantages of allowing used fuel rods to decay (reducing thermal load and other management challenges) over a specified time frame (e.g. 90-120 years) is consistent with allowing the evolution of reprocessing system capabilities.

7. The governing ethical principles of informed choice can and should be part of the selection of the optimal integrated nuclear residuals system with respect to both the impact of nuclear facilities on affected parties and the relationship between the obligations of the current (user) generation and future generations. Both

terms – informed and consent – are crucial to these selections. And each option must be evaluated holistically to determine their conformance with this principle. The current baseline is clearly troubled in respect of both terms.

In order to assess the issue whether the current baseline for nuclear residuals is the optimal one, we must have in mind what it is that we are trying to manage and the fundamental technical factors about which there appears to be agreement. In respect to **civilian nuclear residuals,** the primary challenge is safely to manage spent (or used) nuclear fuel from the current generation of nuclear power plants. There are in addition **residuals from the operation and maintenance** of these power plants and the longer term issue of how to **manage or de-commission - the power plants themselves** after they have been taken out of service.

Spent nuclear fuel, when initially removed from the nuclear power plants themselves, needs to be cooled in pools of water for at least 5-8 years. Subsequently, the used fuel is often and increasingly transferred to dry storage in concrete casks to provide space in the spent fuel pool for fresh used fuel. There is agreement that these casks will safely store the used fuel for from 100 to 150 years. In less than 30 years, half of the radioactive materials in the fuel – those that produce the most radioactive decay energy and therefore require the most heat dissipation and protective shielding actually decay – give off their energy and becomes inert or lifeless. But since there are other very long – lived radioactive materials still in the used fuel even after it has decayed for more than a century, there is agreement that the fuel (if components of the fuel are not to be reused) should be disposed of permanently in a deep geologic repository. It has been agreed for nearly 30 years that ultimate disposal is desirable in a deep geologic repository that does not require active control or human intervention.

There is a caveat, however – in the phrase "if the used fuel is not to be used again". Because we do know that the energy that is still there when the fuel is it is considered "spent" and taken from the current generation of nuclear power plants still has between 95 and 99% of its radioactive energy and can be recycled or reprocessed (taken apart - separated) to "recover" most of that energy.

We have known ever since the defense reactors first began to operate – and we did, in fact, reprocess the fuel – how to recover the material from which recycled nuclear energy can be generated. We were able to "produce" nuclear weapons only because we could separate the radioactive weapons materials needed to make bombs from the used fuel in the reactors. The problem is that we did not know how to manage efficiently the wastes which remained and/or the materials we used to "break down" the used fuel. We have been trying to learn how to manage those wastes from nuclear weapons ever since. And although the learning has not been easy, we are getting better at it; and meanwhile several other countries have moved ahead to develop their own approaches to recycling nuclear fuel and managing the wastes[15]. But the United States did not evolve the recycling technology as it transitioned totally away from defense production to the non-defense uses of nuclear power and hence gained little additional understanding of how to anticipate and manage the wastes generated by reprocessing in ways that would be required under contemporary environmental regulation.

Taking all of these factors into account, where then does that leave us as we try to address the options for spent (or used) nuclear fuel and what is classified as High Level Waste:

Used Nuclear Fuel

The options for used nuclear fuel considered are:

1. Maintain current course with Yucca Mountain

[15] It should be noted that foreign systems are built on the foundation of lessons learned by the US program.

2. Establish Regional Storage Facilities, Continue Yucca Mountain Licensing and Require Pilot Demonstration, Consent and Compensation
3. Establish Fuel Recycling as Immediate Goal, Maintain Storage at Reactor Sites
4. Redefine and Restart Search for Federal Repository

Option 1 – Maintain Current Course with Yucca Mountain

This option maintains the current course and policy. The NRC is reviewing a license application for disposal of both used nuclear fuel and vitrified high level waste at Yucca Mountain. While the outcome of the NRC review of the license application is uncertain, it is reasonably anticipated that legal challenges would follow if the NRC seeks to grant the proposed license. Furthermore, the State of Nevada is very likely to continue strong opposition to the repository, with substantial obstacles and delays associated with actual implementation, including opposition to granting necessary permits and approvals for rail transportation of nuclear materials to the site, water rights for operations, and other actions that may be necessary under systems for regulating hazardous wastes, air emissions and wastewater discharges. NRC license review is anticipated to require 4-5 years, and direct legal challenges to the license ruling may take at least an additional 5 or more years to resolve. Additional implementation delays related to a variety of other permitting intergovernmental jurisdictional disputes can be expected. These could give rise to additional statutory change that may itself be contested. Almost any estimate of how long it will be before the path to Yucca resolution is clear is speculative. And even then additional estimates about when material would actually move to the site would involve forecasting when, for example, the major investment in the necessary railroad and related transportation infrastructure currently envisaged for transport of SNF to Yucca would be completed. This option continues the top-down approach of imposing a repository on an unwilling recipient locale, one that does not benefit from nuclear energy production, and without compensation.

Option 2 - Establish a Reference Storage Period; Regional Storage Facilities; Continue Yucca Mountain Licensing; and Require Pilot Demonstration, Consent and Compensation

Establishing a reference storage interval of 90 years for aging of used nuclear fuel prior to disposal provides (i) radioactive decay time of approximately three half-lives of the primary near-term heat producing radionuclides (i.e., cesium and strontium) reducing the thermal load on a repository and allowing for reduction in the needs for active ventilation of the repository and shielding, (ii) time for the nation to explore whether or not to pursue used fuel recycling in a manner consistent with safety, security and economic requirements and prudent technology maturation, (iii) time for pilot demonstration of the validity of assumptions inherent in the license application for Yucca Mountain, and (iv) modification of siting processes to include consideration of consent, equity and compensation. As part of this option, the used fuel aging period would be established from the time of removal from the reactor, and the period would be distributed between the time at the reactor site (both in the spent fuel pool and in dry cask storage) and at regional aging facilities.

We specifically propose that the program set out to identify and actually create three to four regional storage and aging facilities. And the "regions" could be based on geography that would site one facility in each quadrant of the country with capacity based on the distribution of nuclear power facilities in that region. Part of the failure in past siting efforts has been the way in which political processes prevailed over the intuitively obvious concept that geographic equity is fundamental to perception of fairness - that used fuel be stored in the region that benefits from the nuclear power.[16] An independent federal commission would be established to site the facilities, with provisions

[16] As discussed,earlier approaches to interim storage facilities failed because of political and then legal impediments to their evolution and implementation. For example, the NWPA provision for a Nuclear Waste Negotiator held promise in identifying new locations for nuclear waste facilities but authorization sunset before the process could come either to futility or fruition. One way to divide the regions is to use the geographical outlines of the four Nuclear Regulatory Commission regions (see Appendix C). It is noteworthy that the first Negotiator (David Leroy) found a number of interested communities willing to work with him but had a much more difficult time engaging the states. Many observers believe that Congress had in 1982 anticipated state

for informed consent on the part of all affected jurisdiction (the host communities, counties and states), initial and on-going compensation for hosting a facility, and a variety of provisions to help assure that these transfer and initial facilities do not become de facto permanent repositories[17]. Siting and compensation may potentially be achieved through a "reverse auction" process, whereby a large sum (for example $1 billion) is available initially for communities, counties and states to work out acceptable approaches for mitigating impacts of hosting the site[18]. Annual storage leasing fees, based on the quantity of material in-storage, would also escalate when the fuel age reached 90 years to provide incentives to minimize the storage interval and transfer it to either recycling or a federal geologic repository.[19] Selection of regional storage facilities would be predicated on (i) meeting necessary safety and technical criteria, and (ii) informed consent and participation in oversight by all the affected jurisdictions including the host community, county and state. Current DOE facilities may prove to be especially attractive because of the large land areas, appropriately trained and knowledgeable workforce, established safety and security measures, and familiarity on the part of the community.[20] Former defense sites may also be considered attractive because of existing infrastructure and large land areas.

The licensing process for a federal repository at Yucca Mountain would continue along its current course with several important modifications. First, a pilot demonstration period would be added as an intermediate step to licensing that would be required to validate where reasonable the assumptions inherent in the performance assessment and safety case, including actual placement, monitoring, and retrieval of a limited quantity of used nuclear fuel and/or vitrified high level waste. Second, approaches for the host state and community to be accurately informed, participatory in oversight, and reasonably compensated would established. Given the "in-perpetuity" nature of a repository, establishment of an independent trust fund or endowment mechanism associated with education and workforce development for nuclear systems (including environmental protection and waste management, energy, medical and industrial applications) should be considered. Third, after conclusion of the NRC license application review, evaluation of potential additional repository options would begin. Thus, Nevada and the

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resistance and provided a specific override process should a state veto the President's designation of a site in its jurisdiction. But Nevada's effectiveness in delaying Yucca's implementation proves clear evidence that in this governmental system, states have very important and relevant governmental authority.

[17] Unless, of course, the interim facility site wants to be – and meets the criteria for consideration as -- a repository site. We dispute one fundamental premise associated with most of the previous nuclear waste siting processes in this nation. We believe that the siting of multiple facilities at places where they are welcome will allow the entire society to entertain a fundamental re-evaluation of the risks and rewards associated with nuclear waste facilities generally, and repositories in particular. Rather than becoming an impediment to a well-developed repository program, we believe interim storage as we propose it will allow the nation to begin this evaluative process anew.

[18] See for example "Compensated Siting Proposals: Is it Time to Pay Attention?", Been, Vicki, Fordham Urban Law Journal, (Vol 21, pp. 787-826, 1993-4) for a review of potential compensation approaches. See also "What's Fairness Got to Do With It? Environmental Equity and the Siting of Locally Undesirable Land Uses," 78 *Cornell Law Review* 1001 (1993); "Conceptions of Fairness in Facility Siting," 5 *Maryland Journal of Contemporary Legal Issues* 13 (1993) "What's Fairness Got to Do With It? Environmental Equity and the Siting of Locally Undesirable Land Uses," 78 *Cornell Law Review* 1001 (1993) and Kunreuther, Howard and Easterling, Doug, *Journal of Policy Analysis and Management*, Vol 15, No. 4 (Autumn, 1996), pp 601-22. As noted above, see page 6) compensation is meant to provide comprehensive support to affected jurisdictions – not just monetary support to win initial support.

[19] We are fully aware that the nation has made several starts toward interim storage in the past And recently the Energy and Water Subcommittee of the House Appropriations Committee have sharply criticized DOE for its failure of DOE to evolve a viable spent nuclear fuel storage/disposition approach.

[20] See "Siting of New Major Nuclear Facilities in the United States: CRESP's Year 2008 National and Eleven Site-Specific Surveys" Report 2, Michael Greenberg, unpublished regarding perceptions of nuclear facilities by communities.

host county[21] would be able to re-evaluate their willingness to participate as a host, if the NRC review indicates that the site provided adequate safety and safeguards.

This approach provides a foundation for maintaining safety, environmental protection, informed consent and equity as the foundation for a publicly acceptable process. It provides a mechanism to demonstrate that the nation can make productive siting progress and allows nuclear power facilities to meet community and corporate desires to move the material off-site. The safety of dry cask storage and transportation of used fuel has been demonstrated. Arguments have been made that consolidated storage provide improved economies and safety, but analysts caution that these efficiencies will likely be realized only if, as we suggest is inevitable, a final repository is not available in the next decade-term. Again we stress that presidential leadership would be required for this option to be effectively proposed and implemented, (A draft of how a president would make the case in the current environment is provided as Attachment B).

<u>Option 3 - Establish Fuel Recycling as Immediate Goal, Maintain Used Fuel Storage at Reactor Sites</u>

Focus on fuel recycling has been a central component of the Global Nuclear Energy Program (GNEP), emphasizing rapid development and implementation of new fuel recycling and reactor programs. Under this scenario, used nuclear fuel would remain at the reactor sites until either recycling facilities are available to accept the fuel (with the potential for storage until processing) or a federal geologic repository was available. Several alternative recycling processes and advanced reactor configurations have been under consideration. Choices include either (i) selecting a mixed oxide (uranium and plutonium) fuel for first stage recycling and using the resulting fuel in existing reactors, or (ii) scale-up and demonstration of a new recycling process and reactor configurations. Key issues to be resolved include technology maturation (for other than mixed oxide recycling), economic competitiveness, and non-proliferation safeguards. Recycling the current generation of used fuel to produce new mixed oxide fuel has been and continues to be used in France, but with the current accumulation of surplus separated plutonium. Disposition of a major portion of United States surplus weapons usable plutonium is to be accomplished by conversion to mixed oxide fuel at Savannah River, followed by use in existing commercial reactors. Thus, major elements of fuel recycling using a mixed oxide fuel program are in place or nearing availability (for example, the mixed oxide fuel fabrication facility is currently under construction at Savannah River Site). Former reprocessing facilities for defense purposes (e.g., H- and F-Canyons at Savannah River Site) would most likely be the most expedient facilities for demonstrating application of current or new recycling approaches as applied to commercial fuel. However, the concerns identified above remain, and in addition, balancing mixed oxide fuel availability (if being produced from both surplus defense materials and civilian used fuel) with utilization rates and economic viability argues towards a slow start up, perhaps with a regional demonstration to clarify operability and costs. Fuel recycling will also generate new high level waste, requiring treatment and final disposition. These factors indicate that this approach, while potentially beneficial in the long run, will not alleviate the need for a near-term approach to used fuel management and securing one or more geologic repositories for used fuel and high level waste.

<u>Option 4 - Redefine and Restart the Search for One or More Federal Repositories as the Focus of Nuclear Waste Facility Siting Efforts</u>

This option essentially sends the United States back to the beginning of the repository siting and development process. It would freeze all nuclear residuals siting activity and have the nation literally begin from scratch. This option highlights and promises to repair the many flawed aspects of the past two decades of nuclear waste policy. It would allow a new administration to adjust the conclusions reached in 1977-8 to the new realities the nation faces and see whether a new consensus could be formed. “Stop everything until we can reassess” is initially potentially attractive from a political perspective because it so fully acknowledges the serious flaws in the process up to date.

But in fact it would likely be debilitating from a national perspective. It would further erode trust in a wide variety of sound technical efforts to develop generic repository criteria. Because it would abandon the current license review process (rather than seeking to amend it and build in what the National Academy of Sciences has called “step by step” processes) it would throw into disarray any serious effort to determine whether the regulatory body that now has the responsibility of conducting a licensing process has developed the required capacity to do so. That is a capacity that the country needs to evolve in any event – and would likely lose or badly dissipate if it were simply shelved for a period of years. A more prudent approach would be to allow the process to continue and attendant challenges to progress while providing contingencies that allow for alternative outcomes (see Option 2).Is it preferable to redirect the licensing effort by legislative changes that are consistent with the principles articulated earlier in this document - for both acceptable siting and improved technical direction for ultimate evaluation of repository standards and time frames.

Vitrified High Level Waste

The options for managing vitrified high level waste considered are:

1. Maintain current course with Yucca Mountain
2. First Emplacement at Yucca Mountain as part of Pilot Demonstration
3. Expand use of WIPP with Consent
4. Include with new search for Federal Repository

Vitrified high level waste has at least three differentiating characteristics from used nuclear fuel. The vast majority of vitrified high level waste currently planned for disposal originates from national defense activities rather than civilian reactors (the exception is vitrified high level waste at West Valley, NY). Vitrified high level waste is incorporated throughout a highly deterioration resistant matrix (glass) that substantially reduces susceptibility to localized failure mechanisms (i.e., it is not subject to release greatly accelerated by localized failure of a barrier layer). In addition, the potential future fuel value of vitrified high level waste is negligible (useful recoverable constituents have already been removed to the extent practical). Thus, disposal of vitrified high level waste should not be delayed for potential reuse, and has added layers of safety not associated with used nuclear fuel. However, storage of vitrified high level waste at the sites where it is produced for a prolonged period also is safe. Vitrified high level waste may be used as part of a pilot program to demonstrate the efficacy of a future repository (see Option 2 for used nuclear fuel). Finally, there are not technical impediments to disposal of vitrified high level waste at WIPP; if the community and State of New Mexico are persuaded that acceptance of this material is both safe and in their interest, then WIPP also provides a viable pathway. Finally, there are not technical impediments to disposal of vitrified high level waste in the salt dome that extends north and east from WIPP. If the Carlsbad community was able to persuade the State of New Mexico, that another repository facility should be located near Carlsbad, it could draw on personnel who now have significant experience with repository management. As a result, the disposal pathway for vitrified high level waste should include consideration of a disposition pathway separate from used nuclear fuel. The selected pathway should be based on realistic projections of availability dates and capacity of potential repositories and life-cycle costs.

Conclusions

The twin issues of energy independence and the need for energy use that dramatically reduces carbon dioxide emissions will require very major and nearly immediate public policy decisions about what portfolio of conservation initiatives and energy sources the nation should pursue. Most of the decisions involve forecasting the trajectory of important technological advances in addition to major infrastructure investment. A primary obstacle to fuller evaluation of the place of nuclear power in that selection process relates to issues associated with safe management of nuclear residuals, especially spent nuclear fuel and high level waste. In fact, these issues do not require the near-term resolution of major technological obstacles. The nation has invested significantly in the management of wastes generated by its defense activities and thus has addressed most technical nuclear waste questions, resolved many and has lessons learned from and at least some path forward for most of the rest. Nevertheless, the public is essentially correct in its general perception that an acceptable process to **locate** storage and disposal capacity for the various residuals from nuclear power generation has not been found. If a timely path can be found to resolve this waste issue – and is able to proceed ahead competently - the actual costs and benefits of nuclear power could be much more readily evaluated. Because the public law and policy shaping the complex nuclear waste issue is truly convoluted, finding an integrated "back end of the fuel cycle" resolution for all of the pieces will depend on unraveling and reweaving the statutory framework that currently confuses both the definitions and management of defense and civilian nuclear wastes. (One can picture the complex set of issues that need to be addressed – and where the nation currently is in relation to what would be needed for a complete strategy - by reviewing the diagrams in Appendix A of this document).[22]

Here we have described why an integrated nuclear residuals strategy is essential and address: 1) why it is imperative to take very early action to quickly take hold of and resolve the current crisis in confidence about whether the nation can actually site a nuclear waste facility and make substantial progress in doing so within two Presidential terms, and 2) delineation of what we believe are the criteria and processes that should be used to shape good public policy. Informed consent and equity are central elements to what we believe is necessary for communities to willingly accept future nuclear waste facilities and overcoming the current siting paralysis.

We propose then a two-pronged plan that will give the nation the time it needs to solve the problems involved in siting, designing and constructing a safe and effective permanent geologic repository and simultaneously take the spent fuel off the hands (and reactor sites) of the nuclear utilities and provide safe and secure storage where these materials are welcome. And the plan would do this using the revenue that the federal government is already collecting from the industry.

The first part of our plan is to set up four regional storage facilities (to establish regional equity) that will act as transfer stations to store spent fuel for up to 90 years before it is transferred to permanent storage. We are not the first to suggest interim storage facilities, but we suggest an innovative approach that should overcome the objections that have been raised to oppose them. One of our innovations is to make informed consent and fair compensation the basis for these regional storage sites. For example, we believe it is possible to use a "reverse auction" to site these facilities. In essence, we suggest that the president announce that the federal government has a large sum, say an initial billion dollars, and request bids from interested communities that detail how they would spend this money to mitigate all the impacts of the facility – those affecting the local community and others - both impacts to their community and others it affects in the surrounding region. Large-tract federal facilities no longer needed for their original purposes are especially attractive. If our citizens are informed credibly of the multiple layers of safety systems to be employed, understand the real national interests involved, and know that they will be treated fairly; this will enable some interested communities to secure the needed support from their publics, state government and others. Another critical element is to set a leasing fee structure that sharply ratchets up for storing used fuel that is more than 90 years old. This will help ensure that these sites do not become de facto permanent disposal sites.

A new independent federal commission would handle the siting process for the regional facilities. After siting, the facilities themselves would be operated by a public corporation designed for the specific purpose (in ways analogous to the Tennessee Valley Authority). These facilities could begin relieving the nuclear storage congestion in less than eight years – allowing effective achievement within a single political cycle.

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[22] See also the very substantial companion legal analysis document , R. Stewart and J. Stewart. United States Nuclear Waste Regulatory Law and Policy, CRESP III report, 2008 (draft).

The second puzzle piece proposes to use the “time and space” we gain from interim nuclear storage to transform the permanent repository standoff. The existing federal law that focuses only on Yucca Mountain has put a straight-jacket on nuclear waste management. We need to alter course while seeking to fully benefit from the work done on these issues so far. Two principles to guide the entire process are: locating the repository where it is safe and where it is welcome because the host community and state believe they are being treated fairly relative to site selection and the balance between benefits and impacts. As to the technical learning, NRC should continue its review the license proposal while we continue to learn lessons from both the Yucca siting process and the processes used at the WIPP facility (where radioactive defense materials are daily being stored permanently and now without controversy). Some of the technical best practice rules are obvious: assure multiple layers of protection, make the development of these facilities into step-by-step pilot projects to test out the designs as the potential sites(s) evolve, and only set standards that are both protective and technically achievable. And, of course, take technical advantage of interim storage: design for “cooler” decayed materials and; consider what repository needs would be if a later decision to reprocess fuel emerges. Under these criteria, Yucca may or may not evolve as a viable repository.

But the major lesson learned from both Yucca and WIPP, as well as international experience, is that is that the affected communities for all nuclear residuals management facilities must be either volunteer or be asked to agree - and not be told – that the facility be placed near them. And potential repository hosts must believe that all decisions about repository implementation will be fully transparent and ones in which they concur. Clearly, the effort to examine other locations for the additional disposal capacity the nation will need should begin again – tapping everything we have learned about repository safety, including what will be the longer term repository needs, what nuclear materials really need geologic disposition and what geologic environments (for example, granite, salt and clay) are most appropriate. As this process evolves, we would hope that Nevada would be willing to reconsider whether Yucca should play some important part in this new more robust and safe system. If so, modifications of the current license application can build in the pilot demonstration steps, more flexible transportation options and reduced heat load factors that the interim storage step facilitates.

It may be that even with strong and persuasive executive branch leadership, the complex perception of nuclear residuals as uniquely horrific wastes cannot be overcome. A new generation of public leadership able to understand and credibly distinguish how key new elements can transform the current public perceptions about nuclear residuals could perhaps quickly to lead to more receptive local and state leadership and a congress willing to grant the needed authority to change a policy stagnant and misunderstood for 30 years. What we know is that the country has not tried an approach that embraces informed consent and appropriate compensation coupled with effective national leadership that sees opportunity, not just threats, in the new economic, energy and national security landscape with which the American people are now coming to grips. The approach presented here promises to remove a major obstacle to using nuclear power to reduce both our dependence on foreign oil and our carbon footprint. The additional factor needed is the political will and effective presidential leadership. The key first steps – ones that will usher in the confidence we need that the paralysis is curable - can be assured in four years and achieved in eight.

Appendix A

As stated throughout this document, the task of developing and implementing an integrated nuclear waste management strategy that addresses all nuclear residuals is daunting. This is in part because the diverse nuclear waste classes defined, and the requirements for the sites at which they are located, in the several statutes that apply are so complex. The diagram below depicts what we do and do not now have in place safely to manage the amounts (current and future) of the many types of radioactive materials for the next 30 and 90 years – and then permanently. It also indicates our current capability to transport these different categories of radioactive to those "safe" places:

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