Washington Internships for Students of Engineering

Cooperative Planning: Building a Sustainable Nuclear Industry

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For my cousin, Brianne.

Preface: A Brief Note from the Author

Please allow me to preface this recommendation by asserting that, in regard to the production of electricity in the U.S., nuclear power generation is **not** the entire answer. It is, however, a necessary **part** of the answer and could be a powerful component of the U.S. energy portfolio in the future. Nuclear power currently generates 20% of the electricity consumed in the U.S.; this is second only to the generation by coal at 50%. (See Appendix A for additional information on sources of electricity in the U.S.) This means that the U.S. is currently dependent on nuclear power and will likely continue to be for the remainder of our reactors' lifetimes, or roughly 20 years. Looking out to the next 50-100 years, nuclear power is an attractive low-emission component with which the U.S. could meet its projected increased energy demands. Ideally, an integrated system of renewable, regional power generation in tandem with habitual lifestyle changes to reduce power consumption is probably **the** answer. That said, I cannot stress enough the mutual responsibility we share to act in the best interest of future generations. As such, this paper addresses both the role nuclear power generation **must** play in such a future as well as the role nuclear power generation **could** play in helping to meet the energy demands of tomorrow.

Executive Summary

With public concern over global warming on the rise and the search for low-emission sources of energy heating up, nuclear power is becoming an increasingly attractive option for domestic electricity production in the U.S. In February of 2006, President Bush launched an initiative aimed at fostering a clean, reliable, and secure supply of domestic energy called the Advanced Energy Initiative. This initiative has the potential to coordinate the numerous, existing nuclear power legislative initiatives into a sustainable strategy for clean nuclear power generation. However, the viability of such legislation has been traditionally dependent on political support of contemporary Administrations and Congresses. If properly coordinated, the currently-proposed legislation has the potential to generate a politically-independent nuclear power industry. Such a strategy would enable the nuclear industry to continue to shoulder its share of electricity generation in the face of both increasing electricity demands and potentially unsupportive politicians.

A prioritization of existing legislation must be structured based on timelines for deployment. First, new plants must be built to meet increasing electricity demands and, eventually, to replace the old plants; the Nuclear Power 2010 initiative and the 2005 Energy Policy Act both aim to accomplish this goal. Second, a strategic network of interim storage facilities must be created to enable the Department of Energy to meet its 1998 obligation to take ownership of the nuclear industry's radioactive waste; section 313 of the 2007 Senate Energy and Water Appropriations Bill aims to accomplish this goal. Third, research and development of advanced fuel cycle technology must be funded; the Global Nuclear Energy Partnership aims to meet this goal. Finally, Yucca Mountain must be licensed and constructed to provide for the permanent disposal of high level radioactive waste; the Nuclear Fuel Management and Disposal Act aims to expedite this process. Additionally, opportunities for the multi-lateral dissemination of information must be facilitated; the Generation IV International Forum and the Trans-Atlantic Nuclear Energy Forum are existing examples of such efforts.

There are barriers to be dismantled before these goals can be realized. For instance, the domestic infrastructure for building new plants does not currently exist. Also, social stigma inhibits the transportation of radioactive waste to potential interim storage sites. Further, undeveloped mission plans prevent some partnerships for advanced research and development from being established. Finally, unrealistic licensing standards combined with an absence of performance-based funding inhibit the Yucca Mountain process. Through coordinated efforts, the solutions to these problems could afford the nuclear industry financial stability, and thus, political independence.

Surmounting these various barriers will encourage domestic economic growth and reinforce public confidence in the domestic nuclear industry. For instance, members of the waning domestic manufacturing industry have already expressed an interest in reviving their operations to accommodate new plant construction; doing so would create jobs for skilled-workers whose jobs have recently been outsourced. Also, the successful transportation of radioactive waste to interim storage sites would bring to light the exemplary safety record unique to the nuclear industry and likely stop the accrual of damages from breach-of-contract lawsuits against the Department of Energy for their failure to take title for the radioactive waste in 1998. Further, the establishment of international partnerships would

fortify continued funding for domestic research and development, and ensure that the U.S. would remain in a position of leadership among the members of the global nuclear industry. And finally, expediting Yucca Mountain would guarantee permanent disposal of high level radioactive waste.

The following comprehensive steps should be taken to enable the political independence of the nuclear industry:

1. Nuclear Power 2010 and the 2005 Energy Policy Act should continue as scheduled.
2. Section 313 of the FY 2007 Senate Energy and Water Appropriations Bill should be modified to place Consolidation and Preparation facilities near both Yucca Mountain and future sites of advanced technology research.
3. Research should be coordinated amongst the various members of the domestic and international technology development communities.
4. Congress should consider, and modify, the Nuclear Waste Management and Disposal Act.
5. Support should continue for programs that encourage international collaboration.

Nuclear Power: A Brief Introduction

With public concern over global warming on the rise and the search for low-emission sources of energy heating up, nuclear power is becoming an increasingly attractive option for domestic electricity production in the U.S. In February of 2006, President Bush launched an initiative aimed at fostering a clean, reliable, and secure supply of domestic energy called the Advanced Energy Initiative. This initiative has the potential to coordinate the numerous, existing nuclear power legislative initiatives into a sustainable strategy for clean nuclear power generation. However, the viability of such legislation has been traditionally dependent on political support of contemporary Administrations and Congresses. If properly coordinated, the currently-proposed legislation has the potential to generate a politically-independent nuclear power industry. Such a strategy would enable the nuclear industry to continue to shoulder its share of electricity generation in the face of both increasing electricity demands and potentially unsupportive politicians.

A full realization of the positive impacts that nuclear power could have will depend on the effective management of time, money, and resources. The individual initiatives will necessarily be advancing concurrently. As such, the funding, licensing, constructing, and operating of each initiative's facilities must be timely and efficient, and must consider the concurrent progress of the collective initiatives. Domestically, the successful integration of the initiatives would spark economic growth, increase security, and decrease environmental impact by developing proliferation-resistant, low-emission technologies. Internationally, successful cooperation would ensure that the U.S. would remain in its current position among the leaders of the global nuclear industry.

Steps to Sustainability

It is a unique and fortunate circumstance that the technology, regulation, and financing of the nuclear industry seem to be synergistically aligning to enable nuclear power to meet increasing energy demands; both internationally and domestically, there is speculation of a renaissance impending. Globally, 27 new plants were under construction in 11 countries as of June 30, 2006 [1]. Domestically, the establishment of financial incentives and a regulatory restructuring have provided sufficient motivation for new plant development. Numerous countries are also looking forward to interim storage facilities, advanced fuel cycle research, and geological repositories. Each of these components is integral in the structure of a sustainable nuclear industry. The challenge now lays with evaluating the respective timelines to deployment, identifying the specific obstructions to achieving those objectives, and expediting solutions to enable deployment.

1. **New Plants:** Nuclear Power 2010

Domestically, the first priority for nuclear resurgence is an initiative called Nuclear Power 2010 (NP2010). The goal of NP2010 is to get two new nuclear power plants licensed by 2010. Coordinated regulatory improvements and financial incentives have motivated a willingness within the industry to make the large capital investment inherent in nuclear plant construction. Additionally, both the Senate and the House seem in favor of appropriating the necessary funds for the project.

In 1989, the Nuclear Regulatory Commission (NRC) made extensive upgrades to its nuclear plant licensing regulations. To put it simply, their new approach moderated the potential opportunities to impede the process with litigations, and combined the formerly separate steps of applying for a construction permit and applying for an operating license. The former disconnects led to significant time delays and loss of capital investment. This breakdown in the licensing system catalyzed with rising interest rates and led to an economic downfall within the domestic nuclear industry during the late-1970s and early-1980s.

By the late-1990s, rising prices in the fossil fuel energy sector began re-drawing investors' attention to the low operating cost of nuclear power; rising concerns over greenhouse gases also began drawing attention to the low-emission nature of nuclear power generation. With positive momentum building, investors were still wary of the high capital investment in construction. To ease these apprehensions, the Energy Policy Act of 2005 implemented numerous financial securities: federal loan guarantees for up to 80% of monies borrowed, tax credits for the first 6,000 megawatts of electricity generated by new plants, and federal risk insurance against possible, unforeseeable delays due to the new regulatory process. Consequently, the NRC expects to receive applications for more new plants in 2007. The successful licensing of these applications would likely motivate applications for more than two dozen new plants over the next three years. [1]. (For a more detailed history of the nuclear industry see Appendix B)

Governmental bodies are financially supporting the proceedings. For instance, the House has appropriated the roughly $54 million requested for NP2010 in FY 2007 [2]. Also, in preparation for the success of NP2010, the Nuclear Regulatory Commission (NRC) has already begun to hire and train staff to expedite the licensing process and oversee the construction of the new plants. In another Congressional show of support, both the Senate and the House have expressed intentions to appropriate the $40 million requested to finance this expansion of the NRC workforce for fiscal year 2007. [2, 3]

2. **Interim Storage:** Section 313 vs. the Onsite Storage Security Act

With the success of NP2010 there will be an increased production of nuclear waste and, consequently, a more pressing need for nuclear waste management. Already, 55,000 metric tons of nuclear waste are being stored on-site at nuclear plants and waste is being produced at a rate of 2000 metric tons per year. There are currently two short-term, or interim, alternatives being proposed by Congress: on-site storage and off-site storage.

The Spent Nuclear Fuel On-Site Storage Act was introduced in December 2005 by members of Congress from Nevada and Utah. This Act proposes storing nuclear waste on-site at the nuclear facilities and transferring the title of the fuel to the Department of Energy (DOE). While this Act would allow the DOE to fulfill its 1998 contractual obligation to take ownership of the nuclear waste, it would not solve the problem of accumulating nuclear waste at nuclear plants.

Alternatively, there is currently legislation in both the House and the Senate that propose off-site interim storage. The House has earmarked $30 million of the $544.4 million it appropriated to the DOE civilian nuclear waste program for fiscal year 2007 to be used for the express purpose of developing off-site interim storage [2]. Section 313 of the 2007

Senate Energy and Water Appropriations Bill suggests using Nuclear Waste Fund monies to site, construct, and operate a network of interim storage sites called Consolidation and Preparation (CAP) facilities [4].

It is the consensus of industry members that off-site interim storage would be a more effective solution than on-site interim storage. With proper planning, the proposed CAP facilities could be located near likely research sites and filled with spent nuclear fuel that could be used to develop advanced fuel cycles.

3. Research and Development: The Global Nuclear Energy Partnership

Advanced fuel cycle technology is another nuclear waste management tactic that would reduce the radiotoxicity, heat load, and volume of high-level waste generated by nuclear power plants. Advanced fuel cycle technologies is a collective term for reprocessing, recycling, separation, and transmutation. The broad scope and high cost of such research necessitates extensive collaboration. In February 2006, President Bush announced plans to form a Global Nuclear Energy Partnership (GNEP) to facilitate such collaboration.

When nuclear fuel is irradiated in a light water reactor, like those that constitute the U.S. reactor fleet, it leaves behind spent nuclear fuel (SNF). SNF still contains over 90% of the energy that was originally present in the fresh fuel. This same SNF is also highly radioactive and gives off large amounts of heat. Without further treatment the SNF will remain hazardous for tens of thousands of years; with further treatment the SNF would remain hazardous for only thousands of years, as pictured below in Figure 1. The proposed GNEP advanced fuel cycle technologies would first separate SNF into it usable components, and would then do one of two things: 1) make fresh fuel reactor fuel or 2) make advanced burner reactor fuel.

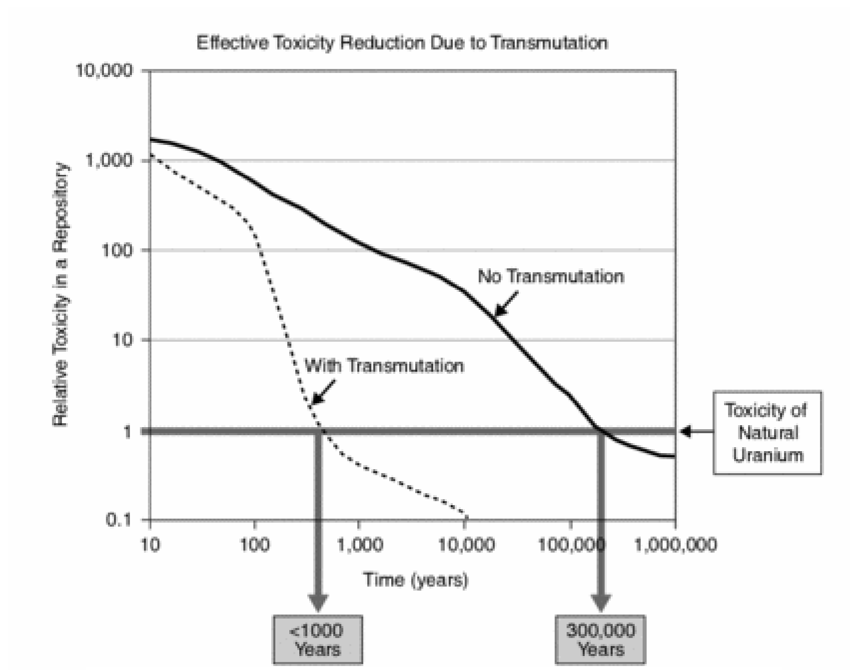


Figure 1: Radioactivity relative to natural uranium versus time, with and without uranium separation and transmutation. [5]

The SNF would initially be separated into three streams: uranium, fission products[1], and transuranic elements[2]. One can think of these streams as "the good, the bad, and the ugly." The uranium is the "good" stream that can be made into new nuclear fuel with relative ease. The fission products are the "bad" stream; they are the nuclear equivalent to exhaust from a car and are of no further use to a nuclear power plant. The transuranic elements constitute the "ugly" stream. This stream contains mostly plutonium and also some highly-radioactive elements called actinides; more energy can be extracted from this stream. The majority of U.S. SNF is roughly 96% uranium, 3% fission products, and 1% transuranic elements [6].

GNEP has a three-step plan for domestic technology deployment: 1) Engineering Scale Demonstration (ESD), 2) Advanced Burner Reactor (ABR), 3) Advanced Fuel Cycle Facility (AFCF). The ESD facility would utilize a process called Uranium Extraction Plus (UREX+) to separate the SNF into the three streams mentioned above. This process has already been demonstrated on a laboratory scale and the ESD would be used to scale-up the operation. The second facility, the ABR, would be used to develop technologies to extract energy from the "ugly" stream of transuranic elements and, in doing so, would reduce the radiotoxicity of the stream. The third facility, the AFCF, would be used to develop large-scale fuel fabrication processes for the commercial deployment of the ABR technologies. The development of the technologies to be demonstrated at the latter two facilities will require significant amounts of time, money, and collaboration among the members of the global nuclear industry. [23]

4. **Permanent Disposal:** Yucca Mountain

The final component of any comprehensive nuclear waste management strategy is the need for permanent disposal of high level waste. In the early-1980s, the National Academy of Sciences (NAS) issued a report at the request of Congress that recommended a deep-geological repository as the most feasible, effective means of permanent storage in the U.S. The Nuclear Waste Policy Act (NWPA) of 1982 began the legislative process of siting, constructing and operating such a facility.

The first step was choosing a suitable site for the repository. Five years were spent finding and evaluating potential sites. In 1987, the NWPA Amendments mandated an in-depth geological characterization at Yucca Mountain, Nevada. In 2002, based on the successful findings of that characterization, President Bush legally sited the repository at Yucca Mountain. (For a more detailed account please see Appendix C.)

Shortly after the 2002 site recommendation, Nevada's Governor, Kenny Guinn, vetoed the ruling based on "bad science, bad law, and bad public policy." As provided for in the amendments, Congress passed a resolution overriding this veto. Later, however, a series of emails made public by the Licensing Support Network detailed the process by which some members of the original United States Geological Survey Quality Assurance team failed to properly document their findings. Yucca Mountain proponents claimed the science was good and that only the documentation was poor. Yucca Mountain opponents said: prove it.

Today it is the task of the DOE and its national laboratories to verify the site characterization data. To do so, integrated computer models – accounting for such variables as climate change, human intrusion, and volcanism through the site– are being developed [7].

1. Fission products: all the elements of periodic table that are not uranium or transuranic elements
2. Transuranic elements: elements heavier than uranium; mostly plutonium

The repository design will be based on this verified data, the current waste forms, and the radiation standards set by the EPA.

Internationally, progress has been made towards geological repositories in Finland, Sweden and France [8].

Obstacles to Achievement

The first section of this document laid out the necessary components of a sustainable nuclear industry; this second section will address the foreseeable obstacles impeding the achievement of the respective components.

1. **New Plants:** Untested Licensing Process, Significant Financial Risks, and Lack of Domestic Infrastructure

Beginning in 2007, both the new plant licensing process and the new financial securities will be tested. However, there are more obstacles than funding and licensing. One of the most significant challenges yet to be met by industry is that of obtaining the necessary hardware for plant construction.

The construction of nuclear plants necessitates multiple, large, high-quality components such as steam generators, reactor vessels, and pressurizers. Being that the U.S. has not constructed a plant in roughly twenty years, the domestic infrastructure for the manufacture of these components no longer exists. Further, with more than 25 plants already under construction in countries across the globe, completely outsourcing this manufacturing would mean waiting in line behind these international customers.

Another, less pressing concern is that of a rule called "waste confidence" that essentially enables continued plant construction. The NRC issued this rule in 1984, and it is good until 2025. The rule is based on three assumptions: 1) deep-geological storage is a viable, permanent option for disposal of High Level Waste; 2) a repository will be licensed for operation by 2025; and 3) interim storage in cooling ponds or dry casks is sufficiently safe until permanent storage is available. However, should any new information arise the NRC will review this rule [9].

2. **Interim Storage:** Existence of Social Stigmas

A significant obstacle impeding the utilization of off-site interim storage is the existence of social stigmas against the transportation of radioactive waste. The transportation of civilian nuclear waste began in 1964 and has never resulted in a release of radiation in the U.S. Both internationally and domestically, high level nuclear waste is transported regularly and without incident. Further, a report by the NAS found that "there are no safety reasons or technical reasons that prevent the safe transport and storage of spent nuclear fuel." [10] However, a currently-licensed interim storage facility is encountering resistance due, in part, to unfounded fears associated with transportation.

The Goshute Band of Tooele County, Utah fought for eight years to get a license for their Private Fuel Storage (PFS) facility. Now, the surrounding Utah community is attempting to take legal action that would prevent the transport of the nuclear waste to this sovereign land

[11]. It is yet to be determined if the actions will be upheld or overturned. In further attempts to block the progress of PFS, Section 313 of the 2007 Senate Energy and Water Appropriations Bill would prohibit interim storage in Utah, if passed in its current form.

A legitimate public concern regarding interim storage is that, without advance fuel cycle technologies or a permanent disposal facility, there is no guarantee that the nuclear waste will ever leave the site.

3. **Research and Development:** Undeveloped Mission

The main obstacle preventing research and development programs from being sustainable in the face of unsupportive politicians is the lack of invested partnerships due to undeveloped mission plans. GNEP is a relatively new and long-term vision whose mission of creating a clean, secure, proliferation-resistant energy economy on a global-scale depends heavily on the viability of future technologies.

The intended path for GNEP technology development was discussed earlier in this document. The first step of that process involves demonstrating the UREX+ reprocessing on a large-scale. Similar technologies exist in the world today and have existed before in the U.S. In 1966, a facility outside of West Valley, New York began reprocessing spent nuclear fuel. Over a period of six years a total of 640 metric tons of waste were recycled. However, due to various economic and political pressures, the facility stopped reprocessing in 1972 [12]. In 1977, the specific method of reprocessing utilized at West Valley was determined to be a proliferation risk, and it became U.S. policy to no longer engage in reprocessing activities.

The process, called Plutonium Uranium Extraction (PUREX) results in a stream of pure plutonium, from which it is relatively easy to make weapons. At the time, the U.S. hoped to set an example for the world to not reprocess. The world, however, did not follow the U.S. example. France, Russia, Japan, and the UK moved forward with their PUREX facilities and have been reprocessing with varying degrees of success over the past 30 years.

The proposed UREX+ process would separate spent nuclear fuel into its usable components without separating out pure plutonium, enabling a more complete utilization of available energy with a reduced threat of proliferation. The uranium stream of the UREX+ process can theoretically be enriched to weapons-grade, but doing so is significantly more difficult than making weapons-grade plutonium from the PUREX plutonium stream.

The second and third stages of GNEP technology development involve fast burner reactors that will theoretically extract more energy from, and reduce the radioactivity of, the UREX+ transuranic stream. However, when properly configured, these burner reactors can become breeder reactors and thus generate, rather than destroy, the plutonium in this stream.

Participation in GNEP would limit the use of these advanced technologies to states already possessing nuclear weapons. A country that is not currently a nuclear weapons state would theoretically not need to develop these technologies because weapon-states would provide the services. However, the GNEP mission plan is not yet fully developed. Countries cannot agree to the terms of a contract that is not yet written.

4. **Permanent Disposal:** Unrealistic Standards, Insufficient Incentives and Public Opposition

There are multiple obstacles to be eradicated prior to the successful licensing, construction, and operation of Yucca Mountain. These obstacles include unrealistic standards, insufficient incentives, and public opposition.

The Environmental Protection Agency (EPA) is the government body designated to set the radiation standards by which the Nuclear Regulatory Commission (NRC) will regulate the safe construction and operation of the repository at Yucca Mountain. Safe, as defined by the EPA, is dependent on the peak dose of radiation that a person would receive if one were to live at Yucca Mountain, eat food grown at Yucca Mountain, and drink milk that came from an animal that ate food grown at Yucca Mountain. In 2001, the EPA issued a standard requiring the DOE to design a repository that would be safe for 10,000 years.

A District of Columbia Circuit Court found this standard to be inconsistent with a 1995 report from the NAS, the that "peak risks might occur tens- to hundreds-of-thousands of years or even farther into the future." As a result, the EPA has proposed amendments to its original standards. The proposed extensions are to be "within the limits imposed by the long-term stability of the geologic environment, which is on the order of one million years." [13] (For perspective, Homo sapiens have existed in their modern form for 40,000 years.)

Faced with the construction and operation of the repository, the DOE lacks two integral incentives for expediting completion: 1) performance-based funding, and 2) performance-based management. In 2001, the DOE issued a report detailing three possible long-term alternatives for integrating these incentives. The various plans mirror those of such organizations as Air Traffic Control, the Internal Revenue Service, and the U.S. Postal Service. The report suggested further evaluation should be performed and that integration of the chosen alternative should begin after the site recommendation [14]. As stated previously, this site recommendation occurred in 2002. However, the DOE has elected to postpone pursuing such integration until after the license application for the repository is delivered to the NRC [15].

Public opposition to Yucca Mountain, simply put, has three motivations: 1) they are Nevadans who do not want the waste in their state; 2) they are members of the general public who are wary of the mass transportation of nuclear waste required; or 3) they are anti-nuclear and believe that a failure at Yucca Mountain would prevent the perpetuation of the nuclear industry. Collectively, the opposition has been taking legal actions to impede the progress at Yucca Mountain for the past twenty years.

As a whole, the opposition likely believes they are acting for the common good, protecting the best interests of the environment and the public. One may even sympathize with the Nevadans' unwillingness to have permanent nuclear waste disposal in their state; while nuclear weapons were once tested on land near the Yucca Mountain site, Nevada is not a state that participates in nuclear power generation. However, opposition to Yucca Mountain based on a fear of nuclear waste transportation is unfounded, as previously discussed in this document. Further, opposition to a repository that is motivated by a desire to bring an end to the perceived hazards of the nuclear power industry is ultimately self-defeating as the

55,000 metric tons of waste that has already been generated would need safe, permanent disposal. (For a more detailed discussion of the this flawed rationalization, please see Appendix D) (For a map of where waste is currently being stored, please see Appendix E)

Barriers to Building Blocks

In many instances, the barriers identified in the second section of this document can be utilized as building blocks to achievement if properly approached. These seeming problems are opportunities to do such things as bolster domestic economy, educate the public, and fortify international partnerships.

1. **Building New Infrastructure for New Plant Fabrication:** Creating Jobs for Domestic, Skilled-Workers

Rather than viewing the current lack of infrastructure for nuclear plant hardware as a barrier, it should be viewed as an opportunity to build the domestic economy. Jobs would be created to facilitate the construction, manufacture, and operation of the new nuclear plants and would necessitate support in the form of goods and services that would in turn generate more jobs. Local communities would especially benefit financially from new nuclear plants.

Broadly speaking, new plants could mean a revival of the domestic manufacturing infrastructure. The recent outsourcing of the car manufacturing industry, for instance, has left a body of willing and able workers without work. BWX Technologies Inc., based in Virginia, has already expressed an interest in manufacturing steam generators, reactor vessels, and pressurizers. [16]

Also on a broad scale, the building of new plants would necessitate an expansion of the regulatory body overseeing the efforts. As discussed previously, the NRC has already begun such activities.

The benefits of having a nuclear plant in one's local community were recently reflected in survey conducted by Bisconti Research Inc. with Quest Global Research Group which found that 76% of Americans living in close proximity to nuclear power plants are willing to see new reactors built near them [1]. On average, a nuclear plant permanently employs 500 workers from the local community and generates about $60 million in total, local labor income annually. Construction also generates 1,300-2000 jobs per plant. [17]

2. **Transporting Waste:** Highlighting an Exemplary Safety Record and Taking Responsibility

The successful establishment of off-site interim storage facilities would provide an opportunity to highlight the exemplary safety record of the nuclear industry and allow for the DOE to fulfill its contractual obligation to take title to the nuclear waste in an effective manner. Additionally, the strategic placement of these facilities could expedite the development of GNEP technologies and the permanent disposal of high level waste at Yucca Mountain.

Currently, the DOE is accruing damages on their breach of contract to take title to civilian nuclear waste. Consequently, those same citizens preventing the transportation of nuclear waste are paying for the waste to stay where it is. These damages will likely stop accruing when the DOE succeeds in taking title to its first cask of nuclear waste. Off-site, interim storage is a short-term solution that would enable the DOE to begin moving waste in the short-term.

Strategically locating and stocking the previously discussed CAP facilities proposed by the Senate could potentially expedite the development of the GNEP technologies. Spent nuclear fuel will be necessary for GNEP research; portions of waste that would be likely candidates for reprocessing could be brought to future sites of GNEP facilities.

The body of waste that is collectively known as legacy waste could be sent to CAP facilities near, or en route to, Yucca Mountain. Legacy waste consists of high-level waste from experimental reactors, old spent nuclear fuel, and defense-generated wastes from nuclear submarines will not, or cannot, benefit from GNEP technologies. The defense waste will not be reprocessed for reasons of national security. The waste from experimental reactors and the old spent nuclear fuel are not prime candidates for the GNEP reprocessing technologies because of their unique nature. Legacy waste is simply waiting for a repository; relocating it to a strategically-located CAP facility would expedite its eventual, permanent disposal.

3. **Developing a Mission Plan for Research:** Fortifying Collaboration and Supporting Scientific Exploration

The successful development of a mission plan for GNEP technologies has potential benefits for consumers of electricity, domestic and international researchers, and Yucca Mountain. A full realization of these benefits would fortify support among these benefactors and, thus, create a more sustainable, politically-independent research and development agenda.

GNEP technologies have the potential to decrease the long-term consumption of uranium in a proliferation-resistant manner. This would be financially advantageous to consumers of electricity and the nuclear industry by ensuring a continued availability of relatively low-cost uranium. It would also enable safe, secure generation of electricity on a global scale.

Professionals at national laboratories and universities would see benefits during the development of GNEP technologies in the form of increased research funding. This increased funding would offer students more opportunities for collaboration with professors and create more jobs for nuclear engineers. As a result, the U.S. could use the development of GNEP technologies as an opportunity to remain at the technological forefront of an international movement similar to that of the Space Race era.

Ultimately, the successful development of GNEP technologies could decrease the duration for which radioactive waste remains hazardous and possibly eliminate the need for additional repositories, until the end of the century, as illustrated below by Figure 2.

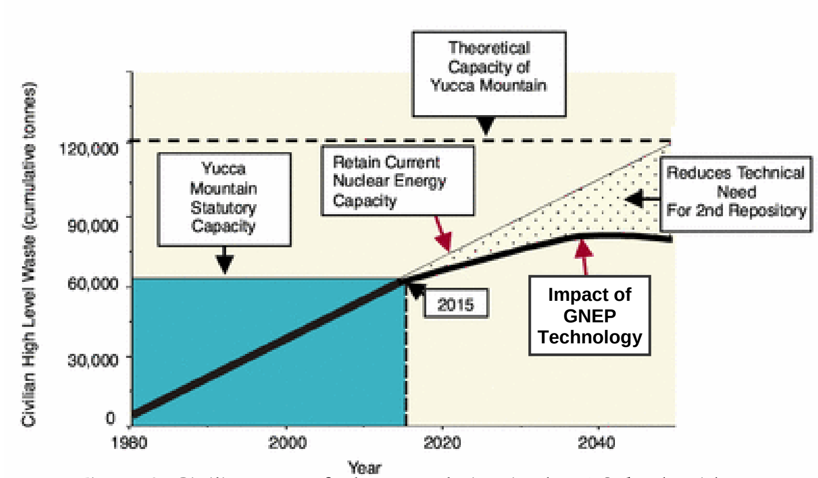


Figure 2: Civilian spent fuel accumulation in the U.S. both with and without advanced fuel cycling. [5]

A study by Argonne National Laboratory (ANL) found that the development of sophisticated reprocessing technologies could reduce the heat load of SNF and thus increase the amount of waste able to be disposed of in Yucca Mountain. Figure 3 below is a graphic representation of this potential increase as a function of the separation efficiency of key transuranics [18].

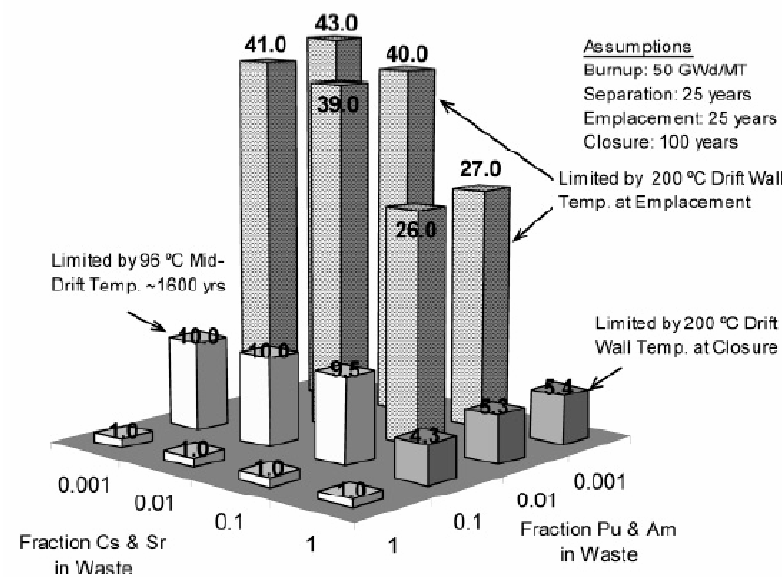


Figure 3: Potential repository drift loading increase as a function of separation efficiency for plutonium, americium, cesium, and strontium. [18]

Both the DOE and ANL found that the development of GNEP technologies could also potentially decrease the duration for which nuclear waste remains more toxic than natural uranium. Figure 1 on page 6 illustrates the DOE version of this decrease. (To see the more detailed ANL version, please see Appendix F.)

Again, extensive collaboration would be necessary to develop these advanced technologies. This collaboration would increase the sense of invested interests amongst the contributing parties and also decrease the potential for duplication of efforts.

4. **Expediting Yucca Mountain:** The Nuclear Fuel Management and Disposal Act

The final element necessary for the creation of a sustainable, politically-independent nuclear industry involves expediting Yucca Mountain by utilizing the financial incentives previously discussed in this document and by evaluating the provisions Nuclear Fuel Management and Disposal Act (NFMD Act). With proper planning and prudent caution, these efforts could enable the timely, cost-effective operation of Yucca Mountain.

The NFMD Act was submitted to Congress in April of 2006. It contains provisions that would, for instance, permanently withdraw the 147,000 acres of land sited for the repository from public use, repeal the statutory limit on the capacity of the repository, set a limit on the duration of time for which the NRC may review the "receive and possess" license that enables operation of the repository, and begin the building of necessary infrastructure facilities – such as railroads – now. The NFMD Act has great potential for facilitating the success of Yucca Mountain. However, caution must be exercised to ensure that the provisions are net beneficial.

For instance, the NRC has already released a letter requesting that the proposed limit on the duration of time for which they may review the "receive and possess" license be set at two years with the possibility of a six month extension [19]. While the NRC supported setting a limit on the duration of review, the standard legal proceedings of the NRC licensing process necessitated a greater duration than that proposed by the Act. It may be that other provisions of the Act could be similarly unrealistic.

Another provision that has positive potential, but necessitates closer inspection, is the provision on funding reform. While it could meet some of the objectives detailed by the 2001 DOE report discussed previously in this document, the legislation must be carefully reviewed to ensure it will be net beneficial. For instance, the DOE does theoretically need access to funds as construction and operation progress, but wasteful spending of funds should not be allowed. Ultimately, the NFMD Act must be considered by Congress before the end of 2006 if any its provisions are to have impact.

It was also mentioned previously that the DOE had elected to postpone selecting an alternate, incentive-based management strategy for the Yucca Mountain project until after the licensing application was complete. Should the DOE renege on their pledge to submit the application by June 30, 2008 it would be prudent to reconsider initiating an incentive-based strategy to facilitate the completion of the license application.

Coordinated Recommendations

The foreseeable future of the human species will involve the generation, transmission, and consumption of increasing amounts of electricity. Nuclear power has the potential to be a powerful component of the diverse energy portfolio that will be required to meet this demand. The ability of the nuclear industry to do so depends on the creation of a cooperative management strategy that will sustain a politically-independent future. With justifiable desires for funding across the board and an increasingly tight budget, a method of prioritization must be constructed that will expedite the necessary and attainable goals.

Proper organization of available resources, such as money and personnel, will be a key factor in maximizing benefits. The system developed should allow for unforeseen changes, such as technological developments or setbacks in the nuclear sector, technological developments in other electric power generation sectors, or a shift in political sympathy toward the development of a specific technology.

In the short-term, both new plants and CAP facilities should be constructed; this will ensure the future ability of nuclear power to meet increasing energy demands and expedite the middle- and long-term goals of GNEP and Yucca Mountain, respectively. In the middle-term, developing the GNEP technologies will enable the global nuclear industry to ensure safety and security during its likely, rapid expansion. In the long-term, efforts need to be exerted to ensure the success of a deep-geological repository for the permanent disposal of high level waste at Yucca Mountain.

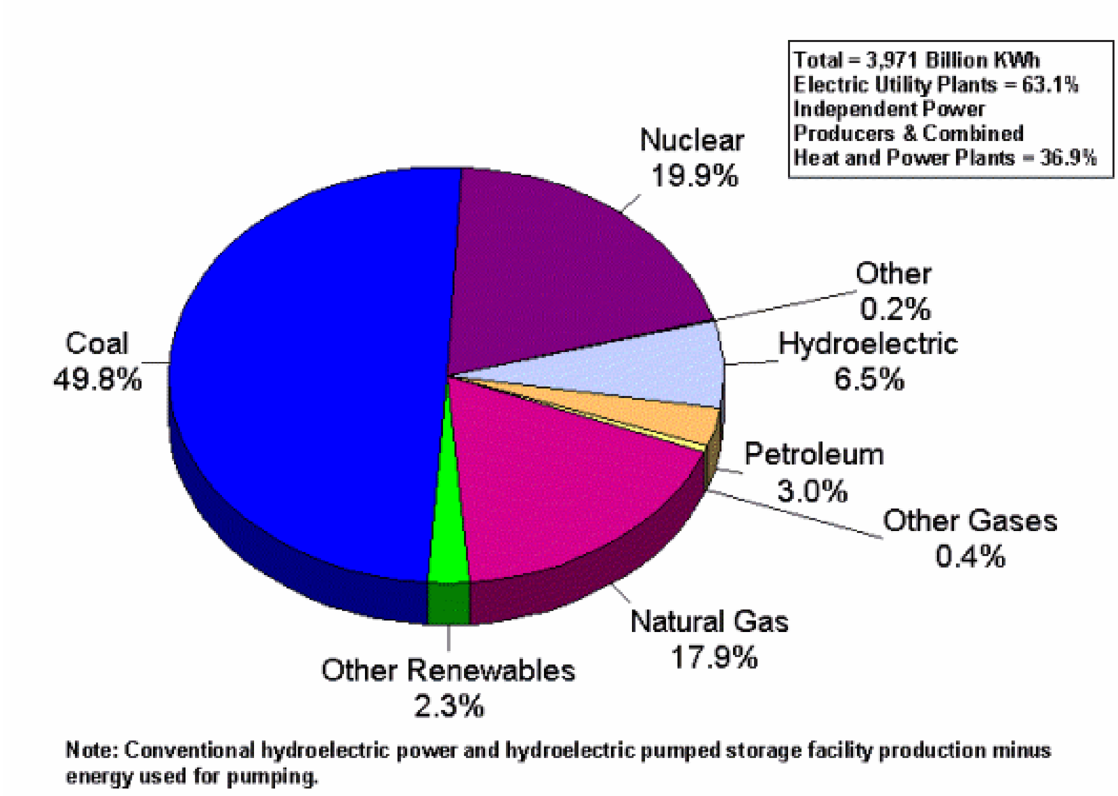
As stated in President Bush's Advanced Energy Initiative, "GNEP does not diminish in any way the need for, or the urgency of, the nuclear waste disposal program at Yucca Mountain." [20] And, despite the daunting technical difficulties of the Yucca Mountain project, the DOE has identified insufficient funding and a redundant, indefinite licensing process as its main difficulties. Consideration of the Nuclear Waste Management and Disposal Act would potentially resolve many of the DOE concerns.

A comprehensive approach to public policies would enable the sustainability and political independence of the nuclear industry. The following steps should be taken to do so:

1. Nuclear Power 2010 and the 2005 Energy Policy Act should continue as scheduled.
2. Section 313 of the FY 2007 Senate Energy and Water Appropriations Bill should be modified to place Consolidation and Preparation facilities near both Yucca Mountain and future sites of advanced technology research.
3. Research should be coordinated amongst the various members of the domestic and international technology development communities.
4. Congress should consider, and modify, the Nuclear Waste Management and Disposal Act.
5. Support should continue for programs that encourage international collaboration.

"With the CAP sites, GNEP and Yucca, I think we now have in place the near-term, mid-term and long-term solutions for our spent nuclear fuel." – Senator Pete Domenici, R-NM.

Appendix A: Electricity generation by source in the U.S for 2004



Source: Energy Information Administration, Form EIA-906, "Power Plant Report."

Appendix B: A Brief History of the Nuclear Industry

A Narrative History …

Domestic nuclear power production originated in the mid-1950s when Dwight D. Eisenhower proposed Atoms for Peace. President Eisenhower's intention was to mirror the precedent set by the United Kingdom for research into non-weapons uses of nuclear power. The next forty years saw the construction of roughly 500 nuclear plants in more than 30 countries; over 100 of these plants were built in the U.S. Commercial-scale plants began gaining prominence in the late-60s and hit a peak in the late-70s. At this point, an Arab oil embargo prompted a broad slow down in the energy sector. However, there was a series of events in the late-70s to mid-80s directly affecting the nuclear industry, both domestically and internationally. First, there was a non-fatal accident at a Three Mile Island reactor near Harrisburg, Pennsylvania. Next, there was a reactor accident at Chernobyl, Ukraine that, according to the Chernobyl Forum, resulted in 31 immediate deaths, extensive environmental degradation, and an increase in fatalities due to cancer caused by radiation exposure. Finally, rising interest rates and a breakdown in the licensing system led to an economic downfall within the domestic nuclear industry.

By the mid-80s, the general consensus in the nuclear industry was that no more nuclear plants were ever going to be built in the U.S. By the early-90s, however, Congress, the NRC, and industry combined their efforts to reform the licensing process to better accommodate both the licenser and the licensee. Later in the 90s and early in the current decade, rising prices in the fossil fuel energy sector and rising concerns over green house gas emissions combined with the financial securities for low-emission sources of energy included in the Energy Policy Act of 2005 to give the nuclear industry the support it needed to begin constructing new plants. Consequently, the NRC expects to receive applications for more than two dozen new plants over the next three years. [1].

A Timeline History …

1951: The first usable electric power from an atom was generated in Idaho.

1954: The Atomic Energy Act was passed by Congress promoting the peaceful use of atomic energy.

1956: The first civilian nuclear power plant comes on line in Calder Hall, UK.

1966-1972: The United States recycles spent nuclear fuel at West Valley, New York.

1968: The Union of Soviet Socialist Republics, United Kingdom, and United States create the Treaty on Non-Proliferation of Nuclear Weapons (NPT), calling for halt to spread of nuclear weapon technology.

1977: Recycling is banned in United States due to concerns regarding PUREX and the proliferation of nuclear weapons.

1979: Due to a faulty sensor, a meltdown occurred at the Three Mile Island nuclear plant near Harrisburg, Pennsylvania that resulted in no direct injuries and led to increased safety regulations for the nuclear power industry.

1982: Nuclear Waste Policy Act is signed into law, establishing a repository site screening process, requiring two repositories to assure regional equity, establishing a schedule leading to federal waste acceptance for disposal beginning in 1998, establishing the Nuclear Waste Fund to pay for the waste program with fees collected on the generation of electricity from nuclear power plants, and requiring that the repositories be licensed by the Nuclear Regulatory Commission using environmental protection standards set by the Environmental Protection Agency.

1986: The DOE indefinitely postponed the second repository site screening program, after much objection from states in the northern mid-west and east where potentially acceptable repository sites were proposed.

1986: A steam explosion, a graphite fire, and meltdown occurred in Chernobyl, Ukraine resulting in fewer than 50 deaths as of 2005, according to the World Health Organization.

1987: The Nuclear Waste Policy Amendments Act passed by Congress sited Yucca Mountain, NV for site characterization for a geological repository.

1992: Congress adopted Section 801 of the Energy Policy Act of 1992 instructing the EPA to establish new site-specific environmental regulations for Yucca Mountain based on "reasonable" safety standards recommended by the National Academy of Sciences (NAS), and the NRC was instructed to revise its repository licensing regulations to conform to the new EPA standards.

1993: The historic 1993 United States-Russia nonproliferation agreement to convert highly enriched uranium taken from dismantled Russian nuclear warheads into low-enriched uranium fuel. As U.S. Executive Agent for this program, United States Enrichment Corporation purchases this fuel for its customers' nuclear power plants. Material for 11,000 nuclear war heads eliminated to date.

2002: Yucca Mountain was federally sited for the construction of a deep-geological repository.

2005: Energy Policy Act includes financial incentives for the first 6,000 megawatts of new nuclear generation connected to the grid

2006: President Bush announced his Global Nuclear Energy Partnership.

2007: Projected application date for new nuclear plants.

Appendix C: A Brief History of Yucca Mountain

Yucca Mountain is the term usually applied to the on-going effort by Congress and industry to permanently dispose of radioactive waste, though in fact it refers to the prospective site of the first permanent high-level waste repository in the U.S. Sometime in the late-70s the U.S. began to give serious thought to their steadily-accumulating stores of nuclear waste. Following a recommendation by the National Academy of Sciences, Congress determined that the U.S. should pursue a deep geological repository as its means of permanent disposal by passing the Nuclear Waste Policy Act of 1982 (NWPA)

The original NWPA established an iterative plan for building two deep-geological repositories. The Act began by outlining a repository site screening process, requiring that two repositories be built, one in the west and one in the east, to assure regional equity. It created the Nuclear Waste Fund to pay for the construction and operation of the repositories; this pool of money was to be generated by fees collected from nuclear power plants on the generation of electricity at a rate of $0.001 per kilowatt-hr. The original schedule called for the DOE to begin accepting waste for disposal in 1998, pending receipt of a license from the Nuclear Regulatory Commission (NRC). Finally, the Environmental Protection Agency (EPA) was to set the environmental protection standards by which the DOE and NRC would abide [22].

The initial site screening of the 1982 NWPA progressed according to its well-laid plan. By the late 1980s potential sites with the necessary geological formations for the first repository were identified in Texas, Mississippi, Washington, Utah, and Nevada. These sites were then evaluated against a set of selection criteria to determine which three of the five sites should proceed to the geological characterization phase of the plan.

Objective witnesses on The Hill at the time will say this is where faith first began to falter in the NWPA process. Throughout the initial evaluation of the five sites, the site in Hanford, Washington was consistently rated as the least desirable site based on the selected site criteria. For instance, the site in Washington was on a bed of fractured rock. The mining community knew from experience that excavating such a site would result in numerous collapses and an inevitable, possibly considerable, loss of life. Yet, the Washington site somehow made it through the evaluation process and was to be included in the site characterization phase of the NWPA with Texas and Nevada.

Meanwhile, the Senate and the House were at odds about how the DOE should perform the site characterization. The Senate wanted the DOE to pick only one site to characterize, instead of characterizing all three and then choosing one as was called for by the 1982 NWPA. The House wanted a commission to review the program and recommend to Congress how best to proceed. During a break in conference, conferees of the House convened.

It was apparent that the Senate conferees were not going to budge, so the House decided to offer a deal: instead of appointing a commission, Congress would decide which site to characterize. At this point, a representative from Washington asked for the Hanford site to be removed from the selection process, presumably due to its poor showing in the evaluation phase. Those present conceded. Next, it was proposed that Texas should be removed from consideration. That site, admittedly, was beneath the second-most prosperous agricultural region in the country. Again, those present conceded. This left Nevada, with no representatives at conference and a very geologically attractive site.

Back from break, the House proposed their deal. The Senate conceded. In 1987 the Nuclear Waste Policy Amendments named Yucca Mountain, Nevada as the site to be characterized for deep geological storage. Two things have continued to happen ever since: 1) the sound scientific characterization of the site, and 2) a relentless, albeit politically understandable, attempt by Nevada to overturn the motion.

On July 19, 2006 the DOE announced it would submit a license application for Yucca Mountain to the NRC no later than June 30, 2006. The DOE estimates that Yucca Mountain will be operational as of 2017.

Source: An interview with Sam Fowler, the Democratic Chief Council, on July 11, 2006.

A full text version of the Nuclear Waste Policy Act is available at: http://www.nrc.gov/who-we-are/governing-laws.html.

Appendix D: Discussion of anti-Yucca, anti-nuclear rationalization

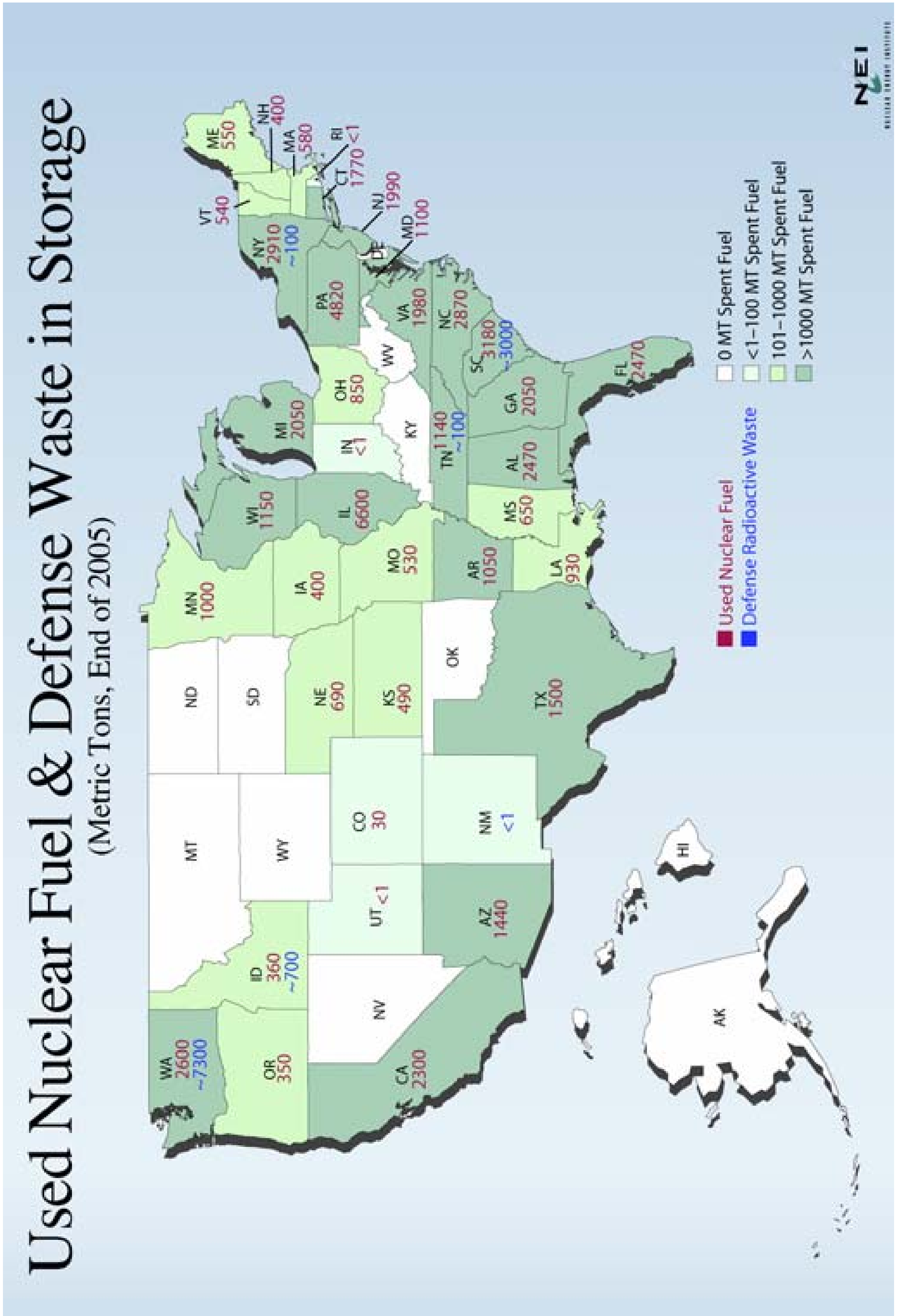
The Flawed Rationalization of the Anti-Nuclear and Anti-Yucca Community…

The classic anti-nuclear rationalization is as follows: nuclear power generation should stop because it is too hazardous; nuclear power generation depends on waste confidence; waste confidence depends on deep-geological disposal. If one were to prevent Yucca Mountain from opening, one would eliminate waste confidence and, thus, nuclear power generation. However, this rationalization fails to take the next step to realize that the end of nuclear power generation would not mean the end of nuclear waste.

If the domestic nuclear power industry were to shut down today, there would still be the over 55,000 metric tons of civilian nuclear waste in need of disposal that the U.S. has already generated. While interim storage is likely safe for hundreds of years, the NRC has only licensed this form of storage for 25 years. Ultimately, the 100 sites in 39 states where nuclear waste is being stored are unlikely to be safe for the 10,000+ years it takes for the waste to decay into something only as hazardous as a natural uranium deposit. What would be the solution then? Perhaps, something proposed by a credible scientific academy, based on years of research and good science: a deep geological repository.

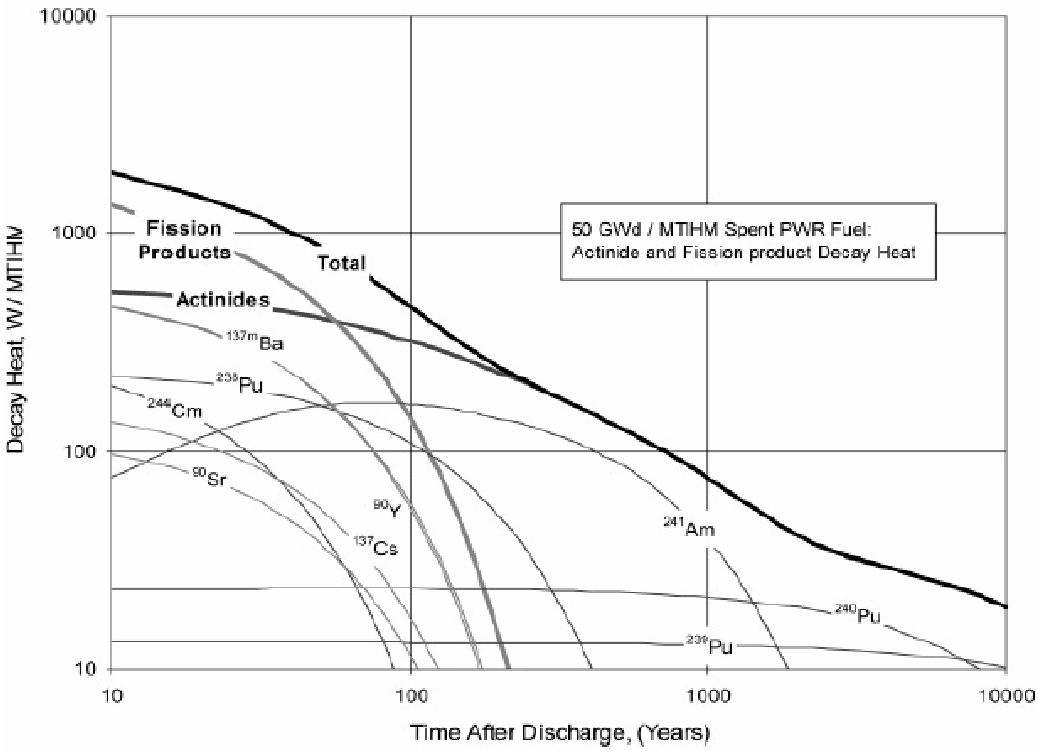
Now the anti-nuclear community would be back to where it started from. Only this time, it would be shouting from the other side of the pro- vs. anti-repository debate line. The solution to this self-defeating opposition will likely come in the form of educating the public about the implication of their actions and, in turn, dispelling the myths surrounding nuclear power and its waste.

Appendix E: Map of interim waste storage by state for 2005 [1]



Appendix F: Details regarding decreased duration of radiotoxicity [18]

Pictured below are the Argonne National Laboratory findings regarding the potential decrease in duration for which nuclear waste would remain radiotoxic as a result of GNEP technologies. The analysis is based on pressurized water reactor fuel irradiated to 50 GWd/MTIHM.



References

1. Nuclear Energy Institute. Retrieved June/28, 2006 from http://nei.org

2. Hiruo, E. (2006). House appropriators keep focus on new reactors in FY-07 funding. *Nucleonics Week, 47*(21)

3. Weil, J. (2006). Incentives in energy policy law still require work, industry says. *Nucleonics Week, 47*(21)

4. Summary of 2007 Senate Energy and Water Appropriations Bill, 109Cong. (2006). Retrieved June 27, 2006, from http://energy.senate.gov/public/index.cfm?FuseAction=PressReleases.Detail&PressRelease_Id=235012

5. U.S. Department of Energy. (2003). Report to congress on advanced fuel cycle initiative: The future path for advanced spent fuel treatment and transmutation research.

6. U.S Department of Energy. (2006). *Report to congress: Spent nuclear fuel recycling program plan*

7. Berry, Dennis at Sandia National laboratory, telephone conversation, & June 6, 2.

8. Seneviratne, G. (2006). IAEA conference debates how long spent nuclear fuel can be stored safely. *Nucleaonics Week, 47*(25)

9. Reemer,Bill at the Nuclear Regulatory Commission, telephone conversation, & July 28, 2.

10. National Research Council, & Russian Academy of Sciences. (2005). An international spent nuclear fuel storage facility -- exploring a Russian site as a prototype: Proceedings of an international workshop.

11. Private Fuel Storage. Retrieved June/24, 2006 from http://www.privatefuelstorage.com

12. U.S. Department of Energy. *West valley.* Retrieved June/12, 2006 from http://www.wv.doe.gov

13. Environmental Protection Agency. *About yucca mountain.* Retrieved July/29, 2006 from http://www.epa.gov/radiation/yucca/about.htm

14. U.S. Department of Energy Office of Civilian Radioactive Waste Management. (2001). *Alternative means of financing and managing the civilian radioactive waste management program* No. DOE/RW-0546

15. Smith, Susan at U.S. Department of Energy Office of Civilian Radioactive Waste Management, telephone conversation, & on July 14, 2006.

16. Weil, J. (2006). US company is ready to fulfill orders for large components. *Nucleonics Week, 47*(21)

17. Clean and Safe Energy Coalition. (2006). *Strong support for nuclear.* Retrieved July/20, 2006 from http://www.cleansafeenergy.org/

18. Wigeland, Roald A., Bauer, T. H., Fanning, T. H., & Morris, E. E. (2006). Separations and transmutation criteria to improve utilization of a geological repository. *Nuclear Technology, 154*, 95.

19. Nuclear Regulatory Commission. Retrieved July/29, 2006 from http://www.nrc.gov/

20. President George W. Bush. *State of the union address.* Retrieved July/25, 2006 from http://www.whitehouse.gov/stateoftheunion/2006/energy/index.html#section5

21. State of Nevada. (1999). *Nuclear waste policy dilemma - the first fifty years: A chronology.* Retrieved June/28, 2006 from http://www.state.nv.us/nucwaste/yucca/nwchron1.htm

22. Nuclear Waste Policy Act of 1982, (2001).

23. Department of Energy. *The Global Nuclear Partnership: Greater Energy Security in a Clearner, Safer World*from http://www.gnep.energy.gov