An Investigation of People's Concerns about Interim Storage of Spent Nuclear Fuel in the United States

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Executive Summary

Storing spent nuclear fuel is a complex issue. Generation of spent nuclear fuel from power plants throughout the United States has created a need for storing this which remains radioactive for thousands of years. Interim storage, a necessary step toward achieving this safe storage goal, presents a number of social, economic, and political challenges. The considerations that must be addressed when dealing with interim storage are the costs associated with storing spent fuel, determining who should be responsible for carrying these costs, understanding how safe the storage options are, ensuring that the spent fuel is safe from potential terrorist attacks, how the public's concerns are heard and addressed, where the waste is ultimately stored (i.e., on-site or off-site in regional facilities), and whether management of spent nuclear fuel should involve reprocessing. Our goal was to investigate how people from different backgrounds feel about interim storage of spent nuclear.

We focused on these considerations because our research indicated that they raise the greatest amount of concerns among members of the public, government as well as power plant managers and their employees. The background chapter discusses issues such as the spent fuel problem, management of spent nuclear fuel, fuel pools, and most importantly dry cask interim storage of spent nuclear fuel.

We investigated the concerns that we found to be most important by identifying members from different groups and interviewing them on how they felt about each of these issues. The groups that we focused on were members of the government, members of interest groups, and members of the general public. We spoke with two members of the public, four members of interest groups, three members of the government, and two plant representatives. We asked these

individuals' questions about how they felt about particular issues concerning interim storage of nuclear waste that would help answer the following research questions:

1. What are the types of concerns that people have with interim storage of nuclear waste?

2. Do people feel that interim storage does an adequate job of containing radiation and is it secure from terrorist attacks?

3. Is the public represented properly in the current system of dry cask licensing?

4. Do different kinds of people express different ideas about the relative benefits and risks of interim storage?

Our analyses lead to several findings:

1. The ability of dry casks to store waste safely does not seem to be a pressing issue in any of the groups we interviewed.
2. Interviewees expressed concerns about the party responsible for paying for dry cask storage.
3. Most interviewees also expressed financial concerns about the potential longevity of companies that maintain dry cask units, compared to the longevity of the dry casks. Therefore we can conclude that cost is an issue that people of various backgrounds are concerned with.
4. The necessary level of security was an issue of disagreement to the individuals interviewed. Some individuals call for dry cask storage to increase security of spent fuel stored in fuel pools. Some individuals call for hardened on-site storage to increase the security of dry cask units to acceptable levels.
5. The interviewee's views on the level of public involvement were varied.

6. The individuals identifying themselves as members of interest groups were among the least positive supporters of interim storage.
7. The only issue considered unanimously among individuals identifying themselves as members of the government was safety.
8. The members of the general public that were interviewed in this report felt that the public was properly represented in the ISFSI licensing process.
9. The plant representatives were most concerned with finding a long term solution to the waste storage issue.
10. The individuals involved in the Maine Yankee CAP were among the most positive supporters of dry cask storage.
11. The reprocessing of nuclear waste is an issue of debate that should not be linked to dry cask storage of nuclear waste.
12. The number of onsite interim storage locations should not affect the ability of regulators to carry out proper cask inspections, because of the USNRC inspection standards that are in place.
13. The equitability of interim storage of nuclear waste at regional facilities is questionable.

Our findings led to several recommendations of two types: policy recommendations and research recommendations.

Policy Recommendations:

1. The federal government should consider creating a new tax on power generated from nuclear reactors that will go toward an account that will fund interim storage of nuclear waste.

2. The federal government should, if they have not already, formulate a plan of action for the scenario of an ISFSI owner bankruptcy.
3. The federal government should create definite standards for nuclear waste storage security.

Research Recommendations:

1. The federal government should investigate the success of the Maine Yankee Community Advisory Panel in order to determine the usefulness of such groups in helping plant operators to communicate with the public during the decommissioning process.
2. A more detailed study of regional storage options should be completed.
4. A further study should investigate how members of the public from various locations feel they are represented in the ISFSI licensing process.
5. A further study should interview more plant representatives in order to determine their thoughts on dry cask storage for an interim time frame.

This report considered the social issues associated with interim storage of spent nuclear fuel. It identified which issues were most important and validated these issues. Interim storage issues are important to consider because spent nuclear fuel is a long lasting material, and currently has no final resting place. The issues involved with storing spent nuclear fuel until a final solution can be found, must be resolved in order to avoid problems, like fuel pools filled to levels that are not secure. At the same time, we must continue to consider the things that are important to us. Rushing to solve this problem is not the solution, we must work together to find out which solutions are the safest, most secure, most cost effective, and most fair.

Abstract

Storage of spent nuclear fuel is a topic that raises many concerns. Without a permanent repository, a number of options for interim solutions have been proposed or implemented. This project combined interview and archival data to understand the range of people's concerns about interim storage for managing a growing stockpile of spent nuclear fuel. Our findings and recommendations address issues of safety, cost, security, and how concerns about them are expressed by different types of stakeholders.

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1 Introduction

In November of 1942, nuclear power emerged in the US when the Chicago Pile-1 power plant began operating at the University of Chicago under military guidance (US DOE, 2008). The first commercial power plant providing electricity to civilians was opened on December 20, 1951, and is known as the Breeder Reactor-1 in Idaho. Since then, the commercial nuclear power industry has expanded to 104 operational power plants located throughout the United States. At the moment nuclear power accounts for a large part, approximately 20%, of the electrical energy production in the United States (Holt, 2003). No new commercial reactors have been built since May, 1996 (Moens, 2005). A major factor that has stunted the growth of this industry is the inability to find a suitable plan for nuclear waste storage in the United States (Macfarlane, 2006). With increasing attention given to the future role of nuclear power as an energy source in the United States the importance of this issue is unlikely to diminish in policy debates (Smith, 2006).

Nuclear waste is defined as many different kinds of radioactive waste which are categorized by levels and types of radiation. Each of these types of waste can be a threat to human and environmental health. One type, spent nuclear fuel, has the highest hazard rating of nuclear wastes (CRS Report to Congress, 2006). When a nuclear reactor operates, it uses nuclear fuel which undergoes a fission reaction in order to create energy to generate electricity. This happens until the fuel can no longer produce energy because of fission reaction's by-products that accumulate inside the material. At this point the nuclear fuel is referred to as "spent nuclear fuel." The fission by-products contained inside the spent nuclear fuel emit radiation until they are stable. Spent nuclear fuel is very hazardous and requires careful handling in order to ensure that the environment, nearby citizens, and the handlers are not exposed to unhealthy levels of radiation. The waste must first be stored for 40-50 years in a fuel pool to cool, before it can be handled. Approximately 53,000 tons of spent nuclear fuel has been produced from nuclear power plants across the United States at a rate of 2,700 metric each year (USDOE, 2006). Reaching a stable state can take up to thousands of years (NSNFP, 2008). Thus, the management of spent fuel is probably the most important issue to address concerning the overall management of nuclear waste.

Nuclear waste storage is a controversial issue because of the complexity of the storage process. There are many areas of concern that have been raised by nuclear consultants and experts, communities surrounding power plants, and members of interest groups. The problems associated with nuclear waste storage range from social and economic to environmental problems. A number of different options have been proposed for nuclear waste storage.

Since 1988 the US government has been attempting to develop a geologic repository located at Yucca Mountain, Nevada. It is very controversial and unclear if it will ever be licensed (Wells, 2006). There are several technical and social issues associated with the plan for Yucca Mountain. For example, how does water move above and below the repository at Yucca Mountain? How might radioactive elements released from degraded waste move away from the repository (YuccaMountain.org, 2008)? To date, there have been six lawsuits filed against Yucca Mountain. One major lawsuit makes the argument that Yucca Mountain violates the U.S. constitution, and that 49 states cannot gang up on one state to solve their problems by burdening Nevada with storage of these hazardous wastes (Nevada, 2003). In addition, news reports have come out in the past stating that some data in the Yucca Mountain project have been falsified (New York Times, 2005), which is relevant to the performance of computer models on water infiltration and climate, which are two major factors in determining the safety of Yucca Mountain as a repository.

Because of the uncertainty surrounding the creation of a central geologic repository for spent nuclear fuel, options for interim storage are being proposed. Interim storage is a temporary storage of nuclear waste either on or off site of nuclear power plants. Temporary can be defined as a time frame from ten, twenty, or even up to a hundred years. Exploration of interim storage methods will serve as an important framework for the future of safely storing nuclear waste in the United States until a more permanent repository such as Yucca Mountain is licensed. Major issues of debate concerning interim storage of nuclear waste include cost, security and safety. Each of these metrics must be weighed appropriately when considering the different options for interim storage plans. We also investigated two other issues related to interim storage of nuclear waste which include: public representation and reprocessing.

Currently, there are two methods of interim storage for storing spent fuel: dry and wet storage. Wet storage involves storing the waste in underground fuel pools. Dry storage typically involves placing the waste in large ceramic casks (Helland, 2001). A number of concerns have been raised about these options. Safety and security concerns about fuel pools are that spent fuel is more vulnerable to terrorist attacks and runs a higher risk of combusting if overheated (Kamps, 2004). The cost of maintaining fuel in fuel pools is higher long-term because it is necessary to constantly maintain a circulating water source to both cool the fuel and act as a shield against radiation (Bunn, 2001). Despite the drawbacks associated with fuel pools, they cannot be eliminated entirely, as they are necessary to cool the spent fuel down before it can be placed in a cask for storage (NAS, 2005). Moreover, dry casks are extremely expensive to construct, and as a result many facilities are not willing to make the transition from using fuel pools to casks.

In addition to the type of storage, the geographic location of the storage sites is yet another decision that has been debated. For example, nuclear waste can either be stored on site or off site of nuclear power plants. If nuclear waste is stored off site, then transportation of hazardous waste is another issue. Cost of transporting nuclear waste is much higher, and there are many potential hazards that could result in transport (NAS, 2007).

There are several gaps in information about interim storage of nuclear waste that are important to understand for policymakers, interest groups, and communities that live around nuclear waste storage sites. Identifying these gaps will provide clarity for these groups when assessing the current state of nuclear waste storage in the United States. First, while many studies compare dry cask and fuel pool storage, none systematically present information about people's concerns. Most reports are either factual descriptions about interim storage methods or policymaking documents that went into detail about licensing, regulations, and statistical comparisons. For example, the NRC gives detailed reports on the different stages of the licensing process, as well as explaining what fuel pools and dry casks are from a technical standpoint (USNRC, 2008). Second, out of all the different issues such as cost, safety, etc. discussed, no prior studies have investigated which issues were the most important and to whom. For example, cost may be of more importance to legislative policymakers whereas safety is most important to the communities where the waste will be stored. Third, we wanted to find out whether the public was being properly represented by the current legislative and regulatory framework regarding nuclear waste storage. Lastly, we wanted to research the topic of regional storage and equity. We define this by asking the question, should the waste be at the place where the energy was produced or should it be sent to communities that never benefited from the nuclear power, and should waste be stored off site at regional locations?

Our project was designed to help better understand all of these issues. We investigated the concerns regarding interim nuclear waste storage of several categories of people. We interviewed eleven people and qualitatively analyzed their responses to our questions. The categories of people we researched were: members of the general public, members of interest groups, government representatives, and plant representatives. We also explored which of the concerns (e.g., cost, safety, security, etc.) is most important and why to each of the interviewees. In addition, in order to better our understanding of the regional storage and equity situation we researched proposed private fuel storage on an Indian reservation in Utah, where nuclear waste from all over the country would be transported and stored. Utah currently does not have its own nuclear power plant, and this issue of equity was of interest to us. The main focus of our project was to investigate nuclear waste storage as a separate issue than nuclear power. We wanted to ensure that our research followed this objective.

We found that safety was not an issue of debate among the individuals interviewed. On the other hand, cost was an issue of debate; from a standpoint of which party should pay for interim storage and who would be responsible for bankruptcies of interim storage facility owners. We also found that security was an issue of debate; particularly in the levels that were necessary. Finally, we found that public representation was an issue to consider; because individuals around some plants seemed to be better represented than individuals around other plants.

In the remainder of this report we will first provide a general background to nuclear waste storage in the United States. We will present information on current methods of storage, and plans for future such as the geologic repository Yucca Mountain. Then we will discuss methods of our research which will include a specific set of research questions, and how we answered them. Our report will conclude by presenting our results and findings, along with a set of recommendations for both policy makers and for future research.

2 Background

This chapter provides an overview on important issues concerning interim storage. The purpose of the background chapter is to provide information that will help the reader understand the social problems regarding nuclear waste, and its context. In the first section we present information about the accumulation of spent nuclear fuel and the major risks that are associated with the waste. Then, in section two we address the two methods of storing spent nuclear fuel as well as describe the promised geological repository at Yucca Mountain. In section three we introduce two specific proposals for interim storage, Hardened on Site Storage (HOSS) and Independent Spent Fuel Storage Installations (ISFSIs). Section three also describes the method for acquiring a license for ISFSIs, as well as comparing two cask storage locations, Maine Yankee and Diablo Canyon. Two regional storage options, NORMS and Private Fuel Storage, and reprocessing are among other important interim storage strategies discussed in the section. Section four details the technology of dry cask storage, where we pay close attention to specific concerns such as cost, safety, security, public representation and reprocessing.

I. The Spent Fuel Problem

Spent nuclear fuel is the byproduct of a nuclear reaction using uranium. Spent nuclear fuel is developed after certain isotopes of elements have undergone a fission reaction. Only certain isotopes of elements such as uranium, plutonium, or thorium can undergo this type of reaction (McCarthy, 1995). The most commonly used element in nuclear power reactors today is uranium (WNA, 2007). Two major forms of uranium exist naturally in the environment today, as a mixture of U-235 and U-238, with an abundance of 0.7% and 99.3% respectively (USNRC, 2008). U-235 is the isotope that is mainly used in fission reactions since the other isotope is not as effective (McCarthy, 1995). The amount of time the nuclear fission reaction takes depends on the amount of U-235 in the rod and the speed at which the reaction is taking place (speed is regulated by graphite rods). According to Birk (2004), “uranium is being used up and fission by-products accumulate and interfere with efficiency until the fuel can no longer effectively produce energy.” At this point the amount of byproducts (which are not fissionable) becomes so great relative to the amount of uranium-235 that the fuel rod is useless for power production and is replaced (Birk, 2004). This rod is no longer useful as fuel and is considered spent nuclear fuel. With every chemical reaction, there are unwanted byproducts that develop, but in the case of a nuclear fission reaction the byproducts include highly radioactive isotopes with very long half lives. Therefore, the spent nuclear fuel produced from a nuclear fission reaction is dangerous to humans for very long periods of time. A list of some of these radioactive isotopes (byproducts) is shown below in Table 1. The type of radiation emitted by these materials is alpha, beta or gamma modes and there is a very large span of half lives. This concept the type of radiation is explained later in this chapter.

Table 1. List of Radioactive Isotopes in Spent Nuclear Fuel (Source: CCNR, 1996)

Isotope Name	**Half Life**	**Type of Radiation**
Thorium-232	14 billion years	Alpha
Iodine-129	15.7 million years	Beta and Gamma
Americium-141	400 years	Alpha
Cesium-137	30 years	Beta and gamma
Radon-222	4 days	Alpha

A. Quantity of Spent Nuclear Fuel

A large reactor produces about 27,000 kilograms or 27 metric tons of spent nuclear fuel per year. There are 104 active nuclear reactors in the United States, which means that this country produces about 2,700 metric tons of spent nuclear fuel each year. Approximately 53,000 metric tons of spent nuclear fuel has been generated by nuclear power plants across the United States since nuclear energy was first introduced as a major form of energy production (DOE, 2006). The amount of spent nuclear fuel produced each year continues to grow. This is due to nuclear power plants increasing amount of overall energy production, which will lead to more production of spent nuclear fuel. By 2010 the amount of commercial spent nuclear fuel is expected to exceed 63,000 metric tons. If proposals for increasing US reliance on nuclear power are followed, the amounts may be considerably higher (Smith, 2006).

B. The Risks Associated with Spent Nuclear Fuel

Spent nuclear fuel is very hazardous and requires careful handling in order to ensure that the environment and the handlers are not exposed to unhealthy levels of radiation. The hazard of the material comes from its tendency to decay radioactively, releasing alpha, beta, and gamma radiation. These types of radiation are called ionizing radiation because they can often change the structure of a molecule in their path (most often they take an electron from an atom in their path and make that atom charged (Bertell, 1986). According to Bertell (1986) this ionization results in a "sudden influx of random energy" and "may either [cause] cell death or cell alteration."

While beta and gamma radiation also are emitted from spent fuel, the radiation of spent fuel is predominantly made up of alpha particles. Because spent nuclear fuel primarily emits alpha particles, the likelihood of exposure is not as high as most people believe. Alpha particles are the largest radioactive particle and travel at the slowest speed (relative to gamma and beta particles) which makes it very difficult for them to penetrate human skin and therefore is usually harmless. These particles travel very small distances in air and can be stopped by a single sheet of paper. The only way in which alpha particles may be harmful to the human body is if they are first ingested or inhaled. Therefore, with minor precautions, the risk of harmful exposure can be prevented (Kose, 2008). A list of radioactive isotopes contained in spent nuclear fuel is shown in Table 1 earlier in this chapter.

While containing the radiation given off from spent fuel is very important, cooling the spent fuel is equally (if not more) important. If spent fuel is not transported to fuel pools to be cooled, or if the fuel pools are not monitored carefully, the fuel could overheat and create a fire that could possibly be more devastating than a nuclear meltdown (Nuclear Information and Resource Services, 2008). If the zirconium cladding used in fuel rods is exposed to air or steam, it will react exothermically and create a fire that would reach a temperature of about 1,000 degrees Celsius (NAS, 2005). A fire of this magnitude could rage on for days.

The effects of radiation from the fuel itself catching fire could cause even more damage than the fire (NIRS, 2008). In fact, according to NIRS (Nuclear Information Resource Service): "A single spent fuel pond holds more cesium-137 than was deposited by all atmospheric nuclear weapons tests in the Northern Hemisphere combined." Exposure to cesium-137 (Cs-137) can cause burns, acute radiation sickness, and death (CDC, 2005). In addition, there is an increased risk for cancer because of high-energy gamma radiation. Therefore, it is imperative that spent fuel be cooled and isolated from any substance which it may react with to ensure that such a catastrophe does not occur.

The management of this radioactive waste requires much attention due to the potential environmental and health effects that can result from spent nuclear fuel. Spent nuclear fuel must be contained in such a way that the public and the environment can be protected. Therefore, the dangers associated with spent fuel must be well known and taken into consideration during the transportation of spent fuel and the construction of storage sites.

II. Current Management of Spent Nuclear Fuel

This section will discuss the current management of spent nuclear fuel which includes both interim storage as well as information on the possibility of a permanent repository Yucca Mountain.

A. Spent Fuel Pools

Fuel pools are typically 40 to 50 feet long by 23 to 26 feet wide by 40 to 43 feet deep (Society for Industrial Microbiology, 2008). These pools are surrounded by a steel plated reinforced concrete wall that is five feet thick (Zhang, 2004). Such pools typically have 20 feet of water above them which serves as a shield that stops radiation emitted from the spent fuel from getting into the environment. The water is typically kept below 100 degrees Fahrenheit, which is a sufficient temperature for cooling spent nuclear fuel (Spent Fuel Pools Newsgroups, 2008). A picture of a spent fuel pool can be seen below in Figure 1.

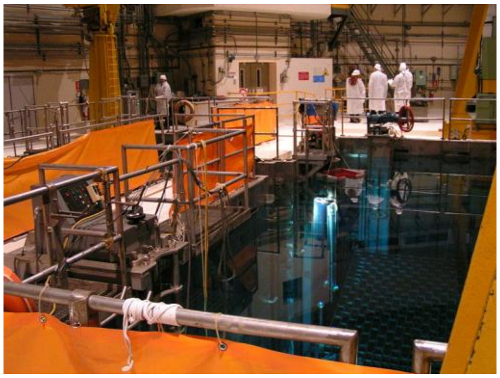

Figure 1. Spent Fuel Pool (source: Wikimedia.org)

A nuclear reactor cycles out part of its core as spent nuclear fuel every one to two years. One year's spent nuclear fuel produced from a reactor is between 20 and 30 metric tons (Zhang, 2008). After 15 to 30 years of spent nuclear fuel storage, the spent fuel pool reaches capacity and the cooled spent fuel in the pool must be moved out to make room for new additional waste (Zhang, 2008).

Cooled waste constitutes any waste that has been cooled for one year in a spent fuel pool. At this point the waste is ready to be moved out of the pool to a dry cask storage container (DOE, 1989). Currently, spent nuclear fuel is only removed from a spent fuel pool when a pool reaches its capacity. However, sometimes the spent nuclear fuel is moved to another spent fuel pool (DOE, 1989).

Spent fuel pools are specifically designed to be large enough to store SNF without compromising the cooling process and safety of the pool. This cooling process relies on the circulation of water surrounding the spent nuclear fuel (Nevada Project Office, 1999), which is monitored constantly to ensure that it does not stop. A stoppage in circulation could lead to overheating of the fuel pool, resulting in release of radioactive material into the atmosphere because of extreme fires, as described above (Nuclear Information and Resource Services, 2008).

The U.S. Nuclear Regulatory Commission states (2002), "A catastrophic meltdown in the spent fuel pool of a nuclear power plant could cause fatal, radiation-induced cancer in thousands of people as far as 500 miles from the site, according to a U.S. Nuclear Regulatory Commission study (Journal News, 2002)."

Fuel pools are located close to the reactor to minimize the distance of transportation of spent nuclear fuel (Citizens and Scientists for Environmental Solutions, 2001). The spent fuel pools are located below ground level, in Fuel Handling Buildings. This below ground storage minimizes the environmental risks of leaks, which would result from wall damage to an above ground pool (the water in the pool cannot escape quickly because the pool is surrounded by rock) (Citizens and Scientists for Environmental Solutions, 2001).

B. Dry Casks

Dry cask storage is another method of storing spent nuclear fuel, which must always follow the initial cooling process of the fuel pools. According to the BRWM (Board on Radioactive Waste Management), dry cask storage systems have the same objectives as fuel pool storage: cool the fuel, shield from radiation, and prevent critical accidents (BRWM, 2006). Traditional dry cask storage is a way of storing nuclear waste in a dry form without using water or mechanical systems. The size of dry casks range from 18-20 feet in height and can weigh over 300,000 pounds when fully loaded (Indian Point Energy Center Brochure, 2008). The internal structure of the cask is designed with a fixed geometry in the shape of a basket (BRWM, 2006). This type of fixed structure inside the cask, with individual compartments, contains the fuel in an orderly fashion. A passive cooling system is used by inserting an inert gas inside the casks; most often this gas is helium. In order to shield the public from radiation, dry casks are usually made of steel, lead, or concrete and are at least 18 inches thick (Helland, 2001, p. 2).

These thick walls also help to block gamma rays. After being loaded with the nuclear waste, the outside walls may reach temperatures up to 100 ^{o}C. Inside the cask, the waste is placed in rods either horizontally or vertically on pads. The material the cask is made of, the size of the cask, and the gaseous internal composition all help protect from radiation leakage. In addition, the casks are designed to withstand natural disasters including tornadoes, floods, or extreme temperature changes (USNRC, 2007, p. 3). No mechanical or electrical components are needed to go along with the casks. A picture of this type of storage can be seen in Figure 2.

Figure 2. Dry Cask (source: thinkquest.org)

This type of storage began when the NRC first licensed the Surry Nuclear Power Plant at Virginia in 1986. The decreasing capacity of fuel pools to store waste has greatly influenced nuclear power plants to turn toward storing spent nuclear fuel via dry casks. Most dry cask storage sites are situated on the east coast of the United States, or in the mid-west near the Great Lakes region (Current and Potential Independent Spent Fuel Storage Installations, 2005). A map of the current dry cask sites is shown in Figure 3.

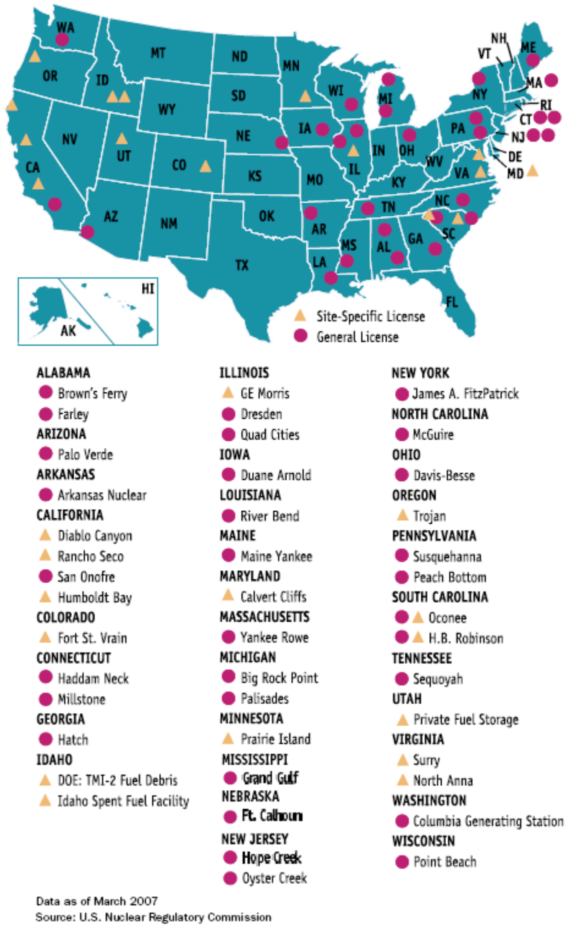

Figure 3. Map of dry cask sites (source: USNRC, 2007)

C. Yucca Mountain Geologic Repository

Much of the spent nuclear fuel residing in spent fuel pools and dry casks was planned to be moved to a central geologic storage facility at Yucca Mountain, located 100 miles northwest of Las Vegas. Many nuclear power plants have depended on disposing of waste at Yucca Mountain. The Yucca Mountain central repository is planned to have a capacity of 70,000 metric tons of spent nuclear fuel, and there is already 53,000 metric tons of waste in the United States (USDOE, 2006). With 104 reactors open in the U.S., creating 20 to 30 metric tons of waste per year, the repository at Yucca Mountain would reach full capacity by 2036 if opened in 2010 (Nevada, 2003).

The Yucca Mountain repository was originally scheduled to begin accepting spent nuclear fuel in January of 1998. However, multiple setbacks have occurred at the site which has caused the scheduled opening of the site to be pushed back to at least 2017 (United States Senate, 2006). These setbacks include: resistance from the state of Nevada, falsified reports about water infiltration and climate, and opposition to spent nuclear fuel transportation (Corbin, 2007). Until Yucca Mountain is opened, cooled spent nuclear fuel will need to be kept in spent fuel pools or moved from fuel pools to dry cask storage units. Although the government has promised for a permanent disposal and storage option for nuclear waste, currently no off-site nuclear storage locations or central repositories exist.

Opening a geologic repository in one central location will also involve transport of radioactive materials, and this venture is costly. Almost 5 billion dollars in funds have accrued since the construction of Yucca Mountain (Science, 2006). These funds were collected by the federal government from the nuclear power plants producing SNF. The government has allocated this money for the management and transportation of SNF to Yucca Mountain. Many nuclear power plants have since brought the federal government to account for failure to comply with past deadlines regarding SNF disposal (Science, 2006). However, resulting from the Energy Act of 2005, the United States government has given nuclear power plants tax credits and subsidized funds in the order of 150 billion over the next 50 years (CRS, 2007).

D. Summary

Many risks result when using nuclear power. Harming the environment and causing life threatening health risks to humans is a significant concern to the public. An equally pressing issue is the concern that we may run out of room at fuel pools altogether within the next few years. A spokesman from Entergy, the parent company of Indian Point says: “The pools are not vulnerable- we’re just running out of room, period.” Estimates suggest that these fuel pools will have reached capacity by 2015 (Energy Resources International). The American Nuclear Society says that if this problem is not addressed before plants reach their maximum storage capacity, they would have no choice but to close down plants which have exceeded the maximum levels of their fuel pools. In order to accommodate these power plants, and due to the lack of success in the Yucca mountain project, an interim storage strategy using dry casks is necessary.

III. Interim Storage using Dry Casks

The purpose of this section is to first provide information on Independent Spent Fuel Storage Installations (ISFSIs) of dry cask storage. It will discuss the different types of licensing of different types of dry casks and the process of registration with the USNRC, among other information about regulations on about ISFSIs of dry casks. In addition, this section will conclude by presenting information about various different forms of interim storage waste methods involving dry casks. These include hardened on site storage (HOSS) and regional storage options.

A. Independent Spent Fuel Storage Installations

Permission from the USNRC must be obtained before beginning construction of a dry cask storage unit. There are two types of licenses issued for dry cask storage unit construction: site specific license and the general license. General licensed dry cask storage units exist at 30 locations in the United States, site specific licensed dry cask storage units exist at 15 locations in the United States (USNRC, 2007). Both license types are described below in detail, and a map of all licensed ISFSIs is presented earlier in Figure 3.

A site specific license application starts with a proposal of a design of the dry cask unit, called an ISFSI (Independent Spent Fuel Storage Installation), which is reviewed by the USNRC for technical and safety issues (USNRC, 2007). Once the USNRC approved the ISFSI design, more analysis of the ISFSI is completed in an Environmental Assessment (EA) and a Finding of No Significant Impact (FONSI), which assess the safety of the geographical location of the ISFSI (USNRC, May 2007). These reports are published together and are open to public review. At this time, the public is issued a Notice of Availability for public comments, and is given an address to mail concerns to (USNRC, May 2007). If no geological problems with the land or technical problems with the casks are found in the five to six months following the release of the EA and FONSI, the dry cask proposal is licensed by the NRC and construction can begin (USNRC, May 2007). This site-specific license allows nuclear waste to be stored in the dry cask unit to be built at that site and is good for 20 years, after which it must be renewed again (USNRC, 2007).

A general license is the request to build a dry cask storage unit for which specifications have already been approved by the USNRC. This licensing occurs in a much smaller amount of time, because the design specs do not have to be re-reviewed. General license applicants must provide adequate evidence that the site will be safe; evidence includes an emergency plan, a quality assurance control plan, a security program, a radiation protection program, and an employee training program (USNRC, February 2007). This process takes about 22 months, and once completed, the licensee performs a dry run, and if all goes well, the cask may be loaded (USNRC, February 13, 2007). General licensing allows nuclear waste to be stored in the dry cask unit for a period of time decided by the USNRC; this period of time may not exceed 40 years (USNRC, 2008).

There are several types of casks, which is mainly dependent on licensing. Casks can be identified as single, dual or multi-purpose (BRWM, 2006). The single-purpose cask is only licensed to store spent fuel (BRWM, 2006). Dual-purpose casks can either be used for storage or transportation. Multi-purpose casks can be used for storage, transportation, or disposal in a central repository such as Yucca Mountain. One decommissioned power plant that has utilized the dual purpose design is Rancho Seco; a decommissioned nuclear power plant in California. In 2002, 493 fuel assemblies were placed into dual purpose casks and stored on site at Seco's ISFSI (U.S. NRC Decommissioning, 2003).

Another way that dry casks are distinguished is whether they are bare-fuel based or canister-based (BRWM, 2006). This type of classification indicates what method was used to load the spent fuel into the casks. In bare-fuel casks, the spent fuel is placed into a basket which is a part of the cask. The cask is also sealed with a bolted lid. In canister-based casks, the spent fuel is loaded into baskets which are surrounded by a thin steel wall. The basket is sealed with a lid, and then the canister can be placed in a dry cask container which is also sealed with another lid (BRWM, 2006).

The process for sealing the canisters starts with workers loading the cask at the fuel pool. The loading of the spent nuclear fuel assemblies into storage tanks takes place under water within the fuel pool (NRC, 2005). The water in the fuel pool acts as a shielding layer so that workers can safely transfer the fuel assemblies into a stainless steel canister (NRC, 2005). The canister is submerged in the fuel pool and the fuel assemblies are loaded. Once the metal canister is removed from the fuel pool it is then welded shut (NRC, 2005). This technique for canister closure welding is an automated process, which means a machine welds the container to minimize workers exposure to radiation (Westinghouse, 2008). Once welded, the canisters are then placed inside a larger concrete container (referred to as a cask) which holds the steel tank (Virtual Nuclear, 2008). After the tank is placed in the concrete cask it can be transferred to the ISFSI loading pad.

B. Hardened On-Site Storage (HOSS) Option

Hardened storage is a form of nuclear waste storage which is intended to be safer and more secure than traditional interim storage options (Thompson, 2003). While dry casks are very secure and robust, and can absorb large impacts without rupturing, they may not be capable of withstanding a determined, concentrated attack. These casks may be hardened by surrounding them with layers of concrete, steel, gravel and other materials which make them even more durable (Thompson, 2003). Hardened storage casks are more likely to withstand a highly focused attack such as an anti-tank missile (Thompson, 2003). Some strong proponents of HOSS feel that they are a better and safer means of storing spent nuclear fuel than Yucca Mountain (NEIS, 2006).

C. Regional Storage Options

This section will discuss two types of regional storage options: NORMS (Nearby or on site retrieval monitored storage) and PFS or private fuel storage. These are ways of storage using dry casks which may provide alternatives to a geologic repository or strictly on site storage.

NORMS is a plan that would use dry casks in regional storage facilities in order to keep the waste as safe and secure as possible for the ecosystem which it is located. Some of the principles that NORMS tries to achieve are designing the safest casks that emit minimal radiation, security and monitoring of the storage site. The difference between HOSS and NORMS is that HOSS deals with adding more physical protection of dry casks, and NORMS deals with geographic locations of where the storage sites should be located.

NORMS principles recognize power plants to be responsible for fund clean ups, and disclose any and all information about decision making to the people immediately surrounding the interim storage location. The NORMS principles act as a code of ethics that power plants should abide by to manage a successful interim storage location (NORMS, 2000).

A second approach to regional storage referred to as PFS or private fuel storage was approved by the USNRC to take effect in Skull Valley, Utah (Private Fuel Storage, 2008). The central idea of PFS involved nuclear waste dry casks from all over the country to be transported to Utah for storage. Utah expressed great resentment towards this decision to use the state as a nationwide interim storage ground (Healthy Environment Alliance of Utah, 2006). Although this plan is now dead, during the licensing process for this plan, Utah representatives stated widespread objection to interim storage of nuclear waste. We wanted to find out whether Utah representatives were rejecting dry cask storage or were they rejecting the public policy decision to use Utah as a storage state.

An alternative option to having one centralized repository or regional storage location would be to have regional storage facilities scattered throughout the nation following NORMS guidelines of safety procedures, etc. Richard Lester, an MIT professor, believes the central repository at Yucca Mountain to be unobtainable and unrealistic. Lester, a nuclear power specialist, feels that it will be far too difficult to store and treat SNF at a central repository. Lester states that "the (Bush) administration should focus on finding regional storage facilities for the nuclear waste," rather than encouraging nuclear energy and reprocessing, which he feels only adds to the problem of spent nuclear fuel (Science, 2006).

D. Summary

There is much controversy as to which form of interim storage is better suited for the United States: dry cask or fuel pools. Experts such as the USNRC (2007), state that dry casks are very safe and easy to use. However, other experts disagree, stating that "Dry-cask storage may sound simple; it is not" (Zorpette, 2001). There is no question that dry cask storage also involves a certain risk factor, but the major issue for discussion is determining whether or not this risk is greater than that associated with using fuel pools. The next section in this chapter will discuss the various arguments presented for and against both types of interim storage.

IV. Analysis of Dry Cask versus Fuel Pool Storage

Both fuel pools and dry casks have strengths and weaknesses as potential interim storage options. Analyzing the issue of storing spent nuclear fuel requires being familiar with these differences. The existing literature suggests that the most central issues that need to be taken into consideration when comparing fuel pools and dry casks are the costs of construction and operation, safety and security factors, public representation, and reprocessing. Two of the main reasons dry cask storage is criticized are because there is little known about the safety and cost of such storage. Also, the process is more complicated.

A. Cost

Capital costs for dry cask storage involves upfront costs and actual labor and material costs. The upfront costs include the initial costs, such as the NRC licensing, engineering, design, materials, equipment, construction of initial storage pads, security setup, and testing (Bunn, 2001). Labor and material fees include the storage system, loading equipment, costs of the casks themselves, and any additional pads and labor. According to Zorpette, the installation of these dry casks are expensive and a complex process (Zorpette, 2001). The total upfront costs are estimated to be from $8-12 million.

The actual cost for an individual dry cask is approximately $1 million. This cost can also be calculated as $60-80 per kilogram of heavy metal (kgHM) which would include the cost of purchasing, labor, loading, etc. of a dry cask unit, instead of being seen as an overall lumped estimate of $1 million per dry cask (Bunn, 2001). It is possible to reduce costs of dry cask storage by re-racking the nuclear waste in order to accommodate more waste in each dry cask.

This method would reduce the number of overall casks necessary which would help to minimize cost.

Although the cost of dry cask storage seems high, compared to fuel pools the long term cost is much less (Bunn, 2001). The maintenance costs of dry cask storage is very small since once the casks are loaded they can sit for decades without too much change. As can be seen in Table 2 below, the overall cost of fuel pool storage is almost double that of cask storage in Japan. The study was also conducted at different scales of 3,000 and 10,000 tons. All results concluded that dry cask storage is more cost efficient over the long term. Also, in comparison to reprocessing spent nuclear fuel, which costs more than $900/kgHM in current European facilities, dry cask storage proves to be more cost effective (Bunn, 2001).

Table 2. Breakdown of Estimated Storage Costs for 5,000 ton Facility in Japan

Cost (100s of million 1998 yen)	Pool storage	Cask storage
Capital cost	1,561	1,310
Construction cost	1,328	105
Cask cost	100	1,195
Decommissioning and disposal cost	133	10
Operations cost	1,395	238
Transportation cost	41	60
Total	**2,997**	**1,608**

Source: Bunn, 2001

B. Safety

Safety is an issue that applies to any form of nuclear waste storage. Safety management refers to measures that protect spent nuclear fuel storage facilities against failure, damage, human error, and other accidents that would cause a leakage of radiation into the public

(BRWM, 2006). In terms of safety, there are advantages and disadvantages to both wet and dry forms of interim nuclear waste storage.

Dry casks are considered safer than fuel pools for a couple of reasons (BRWM, 2006). First, there is less fuel in a single dry cask than there is in spent fuel pools. Less radioactive material means less risk in case of an accident. Usually, several dry casks are used to store the nuclear waste in a particular location. Second, dry casks are designed to ensure adequate passive heat removal and radiation shielding for regular operations as well as in the event of a tip over, and some protection against external assaults (NAS, 2005). Fuel pools do not use a passive heat removal system; they require constant monitoring in order to ensure that cooling is effective. However, research is still being done in order to find out the long term effects of storing nuclear waste in dry casks (Bunn, 2001).

While the use of fuel pools cannot be eliminated entirely (namely because they are needed to allow waste to cool down before they can be transferred to another storage site), many members of the scientific community, as well as members of various environmental agencies, feel that fuel pools are being used more than they should be. According to the Nuclear Information and Resource Service, "Fuel pools were not designed for more than temporary storage (NIRS, 1997)."

As stated earlier, the maintenance of dry casks is much more cost effective than that of fuel pools. In addition, the maintenance process is much simpler because it is a passive and dry form of nuclear waste storage. This dry form of storage brings down the likelihood of human error when maintaining the nuclear waste (Zhang, 2007). In fuel pools, the levels of water in these pools must constantly be monitored to ensure safety (Zhang, 2007). Note however, that dry casks must still be monitored regularly in order to ensure that the temperatures of the dry casks are not reaching critical levels. Protecting radiation levels and monitoring temperature are some of the many precautionary measures that nuclear power plants take to endure safety.

C. Security

Whether or not dry casks are safer from terrorist attacks than fuel pools is debated. For example, Wald argues that a terrorist attack on a spent fuel pool could be worse than the Chernobyl accident in the Soviet Union (Wald, 2003). However, the NRC believes that the study was wrong and that fuel pools are not vulnerable (Wald, 2003). This issue will here on out be referred to as "security," in the same manner as BRWM defined it: measures to protect spent fuel storage facilities against terrorism, sabotage, attacks, or theft (BRWM, 2006).

If a terrorist attack potentially drained a fuel pool of all its coolant liquid, it could lead to a fire (BRWM, 2006). A fire from a fuel pool would release radioactive materials into the surroundings. This type of attack could potentially make fuel pools very dangerous.

The Spent Fuel Storage Licensing document legislated by the US NRC contains the licensing requirements for the independent storage of spent nuclear fuel (USNRC, 2007). The design of some of the cask systems do provide protection against attacks, but were not designed with this strategy. The regulations require that the dry cask storage facilities (ISFSIs) must be located in a protected area of a nuclear power plant site. A trained, armed force must provide surveillance of the dry cask storage site (BRWM, 2006). The NRC believes that even if terrorists were to take over a dry cask site the amount of damage to the casks would be very minimal.

However, the Army Field Manual FM-25, May 1967 states that 150 pounds of high explosive (PETN) can blow over a six-foot deep twelve foot diameter crater in concrete that is reinforced with heavy steel. These types of explosives can be carried in normal sized backpacks (New England Coalition, 2004). Thus, there is controversy as to whether or not terrorists would be able to damage dry casks enough to expose unhealthy amounts of radiation.

In the aftermath of the September 11, 2001 attacks, studies have been conducted to provide a better assessment of possible terrorism at dry cask storage sites (National Center for Public Policy Research, 2001). Sandia National Laboratories analyzed the response of dry casks to potential terrorist attacks in a number of ways (BRWM, 2006). Sandia analyzed three vertical casks and one horizontal design with an airline traveling at high speed directly into these casks. Most of the results from these tests are classified by the Nuclear Regulatory Commission; generally the results showed that some attacks would damage dry casks (BRWM, 2006). However, this damage did not cause radiation leakage. The predicted releases of radioactive material, mostly noble gases, would be very small.

The closed, secure system of dry casks provides a robust and seemingly impermeable method of securing of the waste. Initial research shows that an airplane impact could damage some types of casks, but the predicted release of radioactive material would be small for that mostly noble gases being emitted (BRWM, 2006). In addition to this, the BRWM report on the safety and security of spent nuclear fuel released in 2004 suggests that plant-specific vulnerability analyses carried out by the NRC might determine that earlier movements of spent fuel from fuel pools to dry casks might reduce the potential consequences of a terrorist attack (BRWM, 2006).

D. Public Representation

Public representation is one of the major gaps in information on current background information regarding interim storage of nuclear waste. This refers to the ability of the public around a planned interim storage site to voice their opinions on issues such as cost, safety, security, etc.

In one power plant region (Maine Yankee), a community advisory group was setup in order to better relations between the public and the power plant company. This is known as the Citizen's Advisory Panel or CAP (Ferdinand, 2008). The Maine Yankee is a decommissioned power plant. Upon decommissioning, Maine Yankee transferred all of its spent nuclear fuel into dry casks (Ferdinand, 2008). The Maine Yankee CAP was established with the intention to increase open communication between the public and plant representatives. It also provides education on the Maine Yankee decommissioning process.

E. Reprocessing

Reprocessing is a potential step in the fuel cycle which scientists believe could be very beneficial to the future of nuclear power by minimizing nuclear waste and maximizing fuel input. Reprocessing is the act of separating fissionable uranium and plutonium from spent nuclear fuel which later can be reused to fuel the nuclear reactor. This method, although costly, can minimize the amount of waste stored at fuel pools and in dry casks (Hippel, 2001; Schlissel, 2008).

Reprocessing is not a new technology; the first reprocessing plant was commissioned in 1963. Today, however, reprocessing is not used in the United States. The reason for this is because the fissionable plutonium that is extracted from reprocessing is weapons grade and reprocessing is not economical (Andrews, 2006; Schlissel, 2008). Since the end of the Cold War, the United States policy has been to limit the proliferation of nuclear weapons. Since this time, federal funding of reprocessing has been restricted to limit the proliferation of nuclear weapons. Yet in 2006 President Bush recommended that cleaner, proliferation-resistant, and more economical forms of reprocessing be considered for the future (Andrews, 2006).

F. Summary

The savings in the cost of upkeep, management and security gives dry casks a clear advantage in overall price and value of a means of storage. However, regardless of the method, there are still many factors that have to be addressed while handling and storing a dangerous substance such as spent nuclear fuel. A summary of all the types of the analysis between dry cask and fuel pool storage based on cost, safety, security, etc. are presented in Table 3. As you can see from Table 3, dry casks are safer, more secure, and less costly.

Each issue is shown in a comparison between dry casks and fuel pools. Overall, costs were compared by judging long term costs. Safety was compared by the likelihood of zirconium fires occurring, and security compared which form of storage was more vulnerable for damage. The other issues involved were quality of public representation and the role of reprocessing. These were broader categories not specifically meant to be classified with either dry cask or fuel pools.

The next chapter of the report will involve research methods in order to better understand people's concerns about the issues below. It will begin by presenting a set of research questions, methods of research, and conclude with methods of analysis for our data.

Table 3. Dry casks versus fuel pools comparison matrix

Types of concerns about interim storage	**Dry-cask**	**Fuel pool**
Cost	Most research stated that dry-cask storage was costly to design and initiate, but no cost thereafter. This initial cost is due to extraction and the construction of the casks (Bunn, 2001).	Very costly to maintain requires more man-power and monitoring, but initial design is cheaper short-term (Bunn, 2001). Requires constant monitoring to make sure water flow is high enough, more cost (Zhang, 2007).
Safety	Less spent fuel concentrated in one area (small and compartmentalized into different casks), meaning smaller fires (Bunn, 2001). Safer since it is dry and uses passive cooling.	Zirconium fires (1000 ^{o}C) can occur easily if water supply is diminished (Zhang, 2007; NIRS, 2002).
Security	Actual damage from terrorist attack is estimated to be small (BRWM, 2006).	Much more vulnerable to terrorist attacks, more damage (Zhang, 2007).
Quality of Public Representation	One of the major gaps in information we wanted to explore.	
Role of reprocessing of spent nuclear fuel	This method, although costly, can minimize the amount of waste stored at fuel pools and in dry casks (Hippel, 2001).	

3 Research Methods

In this project, our main goal was to investigate how the public felt about interim storage of nuclear waste and what their concerns are. In this chapter we will present our research methods for investigating these issues. We will first present our research questions. Next, we will discuss our methods for obtaining data and, finally, discuss our approach to analysis.

I. Research Questions

Our research questions relate to understanding views of people about important issues regarding nuclear waste interim storage. We specifically wanted to understand their views about cost, security, safety, and public representation. We sought to answer four research questions.

First, what are the types of concerns that people have about interim storage of nuclear waste?

The first question allowed us to investigate issues involved with nuclear waste storage that we may not have anticipated. Our background research suggested that people are concerned about cost, security, etc. However, there may be other issues which may not have been considered.

Second, do people feel that interim storage does an adequate job of containing radiation and is it secure from terrorist attacks?

This involves safety and security issues concerning interim storage of nuclear waste. We wanted to understand how people feel about the general safety and security of interim storage sites and whether people believe that the radiation is contained. Nuclear waste on-site storage sites are located throughout the United States and in many cases in very densely populated areas.

Third, is the public represented properly in the current system of dry cask licensing?

One of the major gaps in information involved information about how the public was represented in the current system of dry cask licensing. We wanted to explore information on this topic in order to fill this gap.

Fourth, do different kinds of people express different ideas about the relative benefits and risks of interim storage?

This question is an extension of the earlier ones. It can involve any topic regarding interim storage of nuclear waste such as cost, equity, safety, or security, etc. The answer to this question allowed us to compare and contrast the views of different groups of people.

II. Methods of Research

We used two methods of gathering data: archival research and interviewing.

A. Archival Research

The first method we used to locate and understand public concerns about interim storage of nuclear waste was archival research. Archival research involves analyzing documents containing information pertinent to answering our research questions on interim storage (ARTS, 2002). Public documents strictly concerning dry cask or fuel pool interim storage of nuclear waste were searched for on the internet.

The main site that was searched was the Nuclear Regulatory Commission's Public Document Room (nrc.gov). Several documents containing public comments were found. For example, public comments regarding the license renewal of the Vermont Yankee and Indian Point plants were found (U.S.NRC, 2007). Most of the public comments found were related to the nuclear power plants and not storage of nuclear waste. Only one document containing public comments about waste storage was found and it was for the Diablo Canyon site located in California (US NRC, 2007). This document was used in the analysis.

B. Interviews

Our second approach to gathering data involved conducting structured interviews of several subjects to answer our research questions. Structured interviews have a specific set of questions in a specific order which are used as a basis for every interview (Practical Assessment Research & Evaluation, 1997).

We split up the interviews into four different categories of subjects: general public, interest groups, government agency representatives, and power plant consultants or representatives, as shown in Table 4. Two of the interviewees were retired from a position in the category we listed them under; they are a retired plant consultant and retired town planner.

Table 4. Number of People Interviewed

Category	**Persons Interviewed**
Member of the general public	2
Member of an interest group	4
Member of the government	3
Power plant consultant/representative	2
Total	11

Two members of the general public were interviewed. One was an editor of an online journal concerning nuclear waste and power. Another was a member of an environmental group situated in Maine. We felt that concerns of members of the public were relevant to answering our research questions, since it would give us an idea of what concerns there are about interim storage.

The group with most interviews was with members of interest groups (four in all). We felt that this was an important category since these were people who were involved in dealing with nuclear waste in an active community. People from the following interest groups were interviewed: Citizen's Awareness Network, Union of Concerned Scientists, Alliance for Nuclear Responsibility, and the Alliance for Nuclear Accountability. People from interest groups are crucial for gathering information for our research because interest groups usually represent people that seek to influence political decisions, and in this case decisions on nuclear waste storage.

Members of the government were the next major group of subjects. Three members of the government were interviewed, 1) a lawyer in the Dept. of Environmental Quality in Utah, 2) a member of the US NRC, and 3) a retired town planner for Wiscasset Maine, which is the location of the Yankee Maine decommissioned power plant. Government representatives are important for our research since they are the direct policymakers of nuclear waste storage issues in the United States.

The last category of people is power plant representatives or power plant consultants. Two members of this category were interviewed. The plant representative interviewed was from the Maine Yankee Atomic Power company. This provided us a view of the Maine Yankee situation from the plants perspective. The plant consultant interviewed worked at many plants and had vast knowledge in the area of spent nuclear fuel storage licensing and was involved in the decommissioning of Maine Yankee Atomic Power Company.

i. Interview Questions

All interviews were conducted by telephone and were recorded. Each subject was notified that the call was being recorded, and their consent was obtained. Four of the interviews were conducted by four group members, and the remaining seven were conducted either individually or in pairs. We wanted to focus on the concerns of the people we were interviewing, not the specific details and numbers of cost, etc. The first question served as an ice breaker and is twofold. First, it gave us an idea about whom we were interviewing and, secondly in what capacity they were involved in the subject of nuclear waste storage:

1. Please tell us a little bit about yourself and what your interests are regarding interim storage of nuclear waste?
   - Would you describe yourself as a member of the general public, a member of an interest group, a member of the government, or a plant representative?
   - In what ways have you been involved in the issues concerning interim storage of nuclear waste?
   - How did you get involved initially in this field of interest?
   - What do you wish to accomplish with your involvement in your organization?

The next question directly asked about the most important issue regarding interim nuclear waste storage. This question was the major starting point for our research. It allowed us to understand which types of people associate more importance with some issues over others.

2. What do you consider to be the most important issue regarding interim nuclear waste storage? Why?
    - Safety, cost, security, etc.
    - (If the issue is a direct concern to the interviewee) What do you feel can be done, if anything, to positively affect this concern?

The next question is a derivation of the previous one. The first part allows us to situate the subject's views based on a particular nuclear power plant site if applicable. This allowed us to compare the situation between, for example, Diablo Canyon which is located in a seismically active area, versus Maine Yankee, a decommissioned power plant. The second part of the question involves the comparison between fuel pools and dry casks. This is another area of debate we wanted to gather information about, weighing each type of storage with the different metrics of cost, security, safety, etc.

3. Do you believe that the use of dry cask storage is a good strategy for your site (or a site, if applicable) for storing spent nuclear fuel? Why or why not?
    - Are you concerned about running out of space in fuel pools?

Our fourth question allowed us to find out what issues people outside of the nuclear industry had brought to the people we interviewed. This question allowed us to indirectly gather information about what people outside of the nuclear realm were concerned about. We also wanted to find out about issues concerning the licensing, regulations, and other process information regarding specific sites.

4. Do you get the sense that the public feels confident in the way they are represented in the current system?
    - Has the public expressed concerns to you directly?
    - If so, what subjects do they bring up most?
    - How do you address these concerns?

III. Methods of Analysis

The data we gathered are qualitative which requires us to use a qualitative data analysis technique. We used qualitative content analysis to analyze our data. This form of analysis involves condensing information such as interviews, field notes, and other types of unobtrusive data in order for systematic comparisons to be made (Berg, 1995).

The categories we used for making comparisons were developed using both an inductive and deductive approach. An inductive approach involves identifying categories or themes based on existing information. We identified five major categories using this method, as described in the background chapter (see Table 3).

In the deductive approach, we formed two additional categories about reprocessing and regional storage. Reprocessing was a recurring piece of information that was shared by the people interviewed. Regional storage was also suggested by three people interviewed. Therefore, we felt it necessary to explore these subjects in our analysis.

Afterwards, we determined whether the individual's response to questions on a specific topic represented little or no concern, represented major concerns, represented concern in some circumstances but not others, or did not comment on the issue. This was done by reviewing the transcripts to see how positively or negatively they felt on each issue. We used this information in our analysis.

We also included demographic information about these individuals. First, we classified what type of group these individuals considered themselves to be part of, as either an interest group, a governmental agency, a plant representative or a member of the general public.

Then, we further organized the data by which plant the individuals interviewed lived closest to. Those who were not affiliated with a power plant site (e.g., NRC regulator and people who worked for national organizations) were excluded in this part of the analysis.

IV. Summary

The main goal of our project was to understand how different groups of people felt about interim storage of nuclear waste. We were particularly interested in what their concerns were and why. We had several research questions that targeted gathering this type of data. We conducted two forms of research: archival and interviewing.

Our method of analysis involved content analysis. We organized the data into six different types of concerns, and further organized the data by associating people with nuclear power plants. In the next chapter, we will discuss the results obtained from gathering data and use the method of analysis discussed in this chapter.

4 Results

Our goal was to get an idea of how people with different backgrounds feel about the issues surrounding nuclear waste. We categorized these issues into six categories. These categories are cost, safety, security, how well the public is represented, issues associated with reprocessing, and private fuel storage. We focused on these six categories because our background and empirical research indicated that they are the issues that raised the greatest amount of concerns among members of the public, government and power plant managers and employees. In the following sections, we provide our findings about each of these. We also wanted to see how positively or negatively each individual felt about the categories that they commented on. These feelings are summarized in Table 5.

A. Cost

One topic we wanted to investigate was what people thought about the costs associated with interim storage, and any suggestions they could make about those costs. Among these issues were whether dry casks were cheaper for long term use than fuel pools, who should be responsible for handling the costs in the event of an emergency, who should be responsible for handling the costs of storing the waste, and who will be responsible for handling the costs in the event that any of the companies go bankrupt.

First, many people consider whether or not dry casks have a cost advantage over fuel pools. Two subjects claimed that using interim storage is cheaper than fuel pools, and suggest this is a reason why dry cask storage may be advantageous over fuel pools. We spoke with the public and government affairs director of a power plant as well as a member of the Maine Yankee Community Advisory Panel who stated that unlike fuel pools, dry casks do not require any moving parts and have lower operating costs. These lower operating costs over time save the company enough money to pay for the erection of the dry cask unit. These claims are consistent with the findings in our background chapter.

Secondly, we wanted to determine what people's opinions were about who they felt should be responsible for handling the cost of an emergency. In our interview with a member of Utah's Department of Environmental Quality, she mentioned that in Utah it has not been clearly established who should be responsible for taking care of this in an emergency. She says she has brought this issue up to the United States Nuclear Regulatory Commission, but the issue still has not been resolved. She mentions that it is still unclear who needs to be responsible for paying the cost of training employees for an emergency. It is also unclear who should be responsible for paying to clean up waste after an incident.

A third issue that was raised was how the individuals we spoke with felt about who should be responsible for covering the costs of storing waste for the interim time period. The individual from Utah's Department of Environmental Quality feels that the costs of interim storage should be handled by the companies that profit from nuclear energy. A member for the Union of Concerned Scientists on the other hand, has been fighting to pass bills which would make the federal government responsible for covering all expenses related to purchasing and setting up casks for interim storage, since the federal government was originally supposed to remove the waste once it was sufficiently cooled in the fuel pools; making interim storage unnecessary.

Finally, in the case of regional fuel storage the representative from Utah brings up the point that we cannot ensure that the companies that plan to take the steps to ensure that private waste storage sites will last as long as the storage site itself. She feels that it is presumptuous to assume that a company can prove that they will be around for tens or even hundreds of years to store the nuclear waste they take in. She wonders what will happen in the event of the collapse of these private fuel storage companies; who will be left in charge of upkeep. An individual from the Alliance for Nuclear Responsibility also expressed similar concerns about who will pay for the upkeep of dry cask units on site of plants that might one day go out of business. He feels that it is unclear who is responsible for keeping the waste safe and secure: “Who is going to be left holding the bill for the long term security, surveillance, [and] maintenance on this?”

B. Safety

We also wanted to determine people’s feelings about how safely waste is stored at interim storage sites. Among the issues that were raised were the risks of zirconium fires, radiation leakage, earthquake damage and casks falling over. As we conducted our interviews, none of the individuals we spoke with expressed any major concerns about radiation leakages, fires, or casks tipping over. However, there were concerns raised regarding seismic activity and the dangers it could place on interim storage.

Many individuals feel that dry casks are well designed and do not have any safety concerns related to them. A former Maine Yankee CAP member stated: “I studied those [casks] in depth, and am very comfortable standing next to them.” First of all, they are short and robust, with minimal risk of tipping over. Secondly, the material that stores the waste has a minimal risk of catching fire. Finally, he stated that in the event that a cask is damaged or its safety is otherwise compromised, the casks can easily be placed inside another cask before any radiation would be exposed to the environment. He then went on to say that storage casks have been designed to last for fifty years, and the government has approved the casks for storing waste for up to twenty years. An individual working at the United State Nuclear Regulatory Commission feels that the casks are very well designed, and goes on to say that: “Our staff have degrees in many areas, these folks do a very careful study of the issues we deal with.” He concludes by saying that the casks do their job well enough to contain radiation and keep the fuel from overheating, and that the casks are designed to be short enough so that he is not concerned that they will fall over.

These experts stated that they were not concerned with the other issues pertaining to the safety of interim storage. None of the individuals we spoke with brought up any concerns about radiation contaminating the environment or nearby communities, nor did they elaborate on the process of transporting spent fuel and the safeguards that have been put in place. Also, they said that they are not concerned about how safely waste is transported. Transportation is a concern to some of the individuals that we spoke with and is related to interim storage because waste must be transferred from the reactor core to an interim site, and there is always a risk of an accident or terrorist attack happening. For example, a retired nuclear engineer emphasized how overblown he feels many of the public’s concerns were regarding the transportation of nuclear fuel, stating: “What the public doesn’t realize is that nuclear fuel moves around this country all the time.”

The only issue of concern pertaining to safety that was raised in our interviews was the issue of seismic activity near storage facilities. A member from the Alliance for Nuclear Responsibility mentioned that he is concerned that the level of seismic activity near many of these sites is underestimated before the site is actually built and that these sites are not required to take any further precautions after the site has been approved. This individual said that in the case of Diablo Canyon, they discovered that the site was at risk of withstanding an earthquake which could cause substantial damage to the casks. However, since the NRC had already approved the site, no one was required to make any changes, and the site remains at risk. This individual also states that if a cask was ruptured in an earthquake, it would need to be transported along the seafront to be repackaged, and this would place it at risk of being targeted by terrorists. He did state however, that dry casks are not at as great a risk of being compromised in an earthquake as fuel pools are.

However, according to public comments from NRC documents, members of the NRC claim that the casks are very safe and are not at risk of being damaged by earthquakes. Transcripts from a public meeting regarding Diablo Canyon showed that the NRC went to efforts to address the issue of seismic activity and the threat to dry casks. A resident expressed concerns about whether or not earthquakes could damage these casks. A senior level advisor assured the individual that these dry casks go through a drop test that can withstand much greater impacts than any earthquake that would be produced near that site. He also said that the dry casks are even safer than the reactor core.

C. Security

The issue of security has been brought to the front of many peoples' minds since the 9/11 attacks, and we wanted to see what people's opinions were about what was being done and what they felt should be done to keep waste secure. The concerns brought up include the issue of whether waste should be stored long-term in fuel pool or dry casks, the risks of airplanes being crashed into dry casks or fuel pools, and terrorists being able to fire missiles at sites. Although many of the individuals that we spoke with felt that although security was important, they did not have any major concerns about how it is being implemented. Yet, many of the interviewees felt that spent fuel storage sites are a possible target for terrorist attacks. Security was commented on in nearly every interview carried out. In fact, some of the interviewees felt that security issues are more of a concern than other safety issues and cost considerations.

The first issue that was raised was whether fuel pools were as secure a storage method as dry casks. A member of the Union for Concerned Scientists feels that fuel should be moved from fuel pools to dry casks as soon as possible, because they are easier to secure. He says: "Spent fuel pools should be emptied to their minimum level" and that plants should "accelerate the transfer of irradiated fuel to dry casks." However, a representative from the American Nuclear Society disagrees, stating that he has no concerns about using fuel pools as means of long-term storage. A representative from the NRC concurs, saying that both fuel pools and dry casks are well designed and that he does not have any concerns about either of them being penetrated by terrorists.

A second issue that people we spoke with brought up as a concern is the risk of airplanes being flown into dry casks. A member of the public associated with the Yankee Maine CAP has expressed that in the event terrorists attempted to crash a plane into a dry cask storage site, it would probably be very difficult for them to strike a storage cask. He also says that even if a plane did strike a cask, the casks would absorb the impact and it would be unlikely that the cask would be ruptured. A member from the Maine Yankee Atomic Power Company also said that the risk of an airplane successfully rupturing a cask is not a significant concern because the casks are well designed and the security issues have been adequately addressed. Unfortunately, the Maine Yankee representative would not comment any further on this issue, because he did not want to compromise security procedures.

However, other individuals that we spoke with did raise a few concerns pertaining to the security of interim storage facilities. The first concern that was raised was that there are a number of storage sites scattered over the country. A Maine Yankee CAP member that we spoke with said that waste should be stored at large regional sites, because this would reduce the number of storage sites around the country and would decrease the likelihood of a site's security being compromised.

A final concern that has been raised is that at some sites the dry casks are left in plain view, which can make them an easier target for terrorists. A representative from the Citizens Awareness Network says that she does not understand why so little is being done to guard these casks or hide them from view. A representative from the Alliance for Nuclear Responsibility says that at a number of these sites no actions are being taken to shield the casks from view. He suggests that an earthen berm should be set up around the site to limit visibility and to act as a shield against missiles. A representative from the NRC feels that earthen berms may not be necessary at every site, but that they are useful not only in hindering terrorist attacks but also for shielding radiation. An individual from the Alliance for Nuclear Accountability agrees that these casks should not be in plain view, but rather than using an earthen berm he suggests that interim casks should be turned into hardened casks which are harder to see and make more difficult targets. He states that we should: "make it (nuclear waste) as safe as possible" and that "hardened onsite [gives] substantial security and physical protection measures."

D. Public concerns and how they are addressed

Individuals have differing views as to how well they feel the public is being represented and how well their concerns are addressed. Some individuals feel that the members of the public are satisfied with how their voices are heard. On the other hand, others feel that the public is very frustrated and feels that it is not listened to. However, one of the individuals we spoke with said that the degree to which the public's voice is heard varies among the different plants.

Some of the interviewees expressed that they feel that the general public is satisfied with how well their voices are heard. A representative from the website Nuclear.com for example says that most communities near nuclear power plants are in favor of the use of nuclear energy, once they get used to the idea and see it is not a safety risk. He feels that this makes the issue of dry cask storage less of an issue in these areas. A representative from the NRC says that he has been very involved in these meetings and points out that the public's questions and comments are listened to carefully in public meetings and NRC members make every reasonable effort to explain and keep track of them. He says: "I feel we are putting forth a significant exerted effort, to be out with the local community explaining what we do from a regulatory perspective and our licensing and regulations of these storage facilities."

In fact, some individuals say that not only do they feel that the public is listened to, but also that their concerns are well addressed. A member of the Yankee Maine Community Advisory Panel says that he has seen numerous complaints and concerns brought up by the public and CAP, and that Maine Yankee and the NRC have addressed these concerns. The CAP members feel that the Maine Yankee plant formed the CAP to allow people to organize into a forum where they can all raise their concerns, CAP members feel that this opportunity has helped the surrounding community adjust to the process.

However, not everyone feels that the public's voice is well heard. For example, a representative from Utah's Department of Environmental Quality stated that the public in Utah is very frustrated with the Nuclear Regulatory Commission and how they have failed to act on the public comments. She feels that the NRC tends to ignore any concerns that the public raises until the law mandates that they act on them. She says that: “The way the things are set up the only way you can insure that your issues are addressed is in an adjudicatory process.” A representative from the Alliance for Nuclear Responsibility also feels that the process is not run very democratically. He says: “This is not a process that is easy for the public to engage in.” He brings up the question of whether we want to use nuclear power if it requires such a high level of confidentiality. He feels that the need for confidentiality in and of itself raises questions of the rationality of the institution of nuclear power: “if a form of energy requires a secrecy that we the members of the community can’t be told [about], then we need to ask the fundamental question; is this a type of power we want to have?”

One of the issues that were brought up by a large number of people is the lack of cooperation of the NRC. A representative from the Citizen’s Awareness Network said that in her opinion, the public has no faith in the NRC, and feel that none of their concerns are taken seriously. She said that at Yankee Rowe, the public felt that the NRC was not giving them any chance of participating in any of the decision making processes. The representative from the Union of Concerned Scientists that we spoke with said that in the licensing process the only time that the public has to object to a site is when the site is first certified by the NRC. The public often is not even told where a cask is being placed, and as a result they often feel blindsided. This representative said that the only way that the public can fight a dry cask storage site from being set up in their community is to sue, and even then it is difficult to get the courts to rule favorably if the public did not first object to the site being constructed.

While there are many individuals who feel the public is well represented, as well as many who feel that it is not, some feel that the public representation varies on a case by case basis. The former nuclear engineering consultant that we spoke with said that: “A responsible plant will open up to the public for comment, but there is no requirement for them to do so.” However, he also says that once a plant gets the operating license for an ISFSI: “The public doesn’t have the ability to say no.” He feels that the public is therefore represented only as well as the plant allows them opportunities to have their voices heard.

E. Issues Associated with Reprocessing

The issue of reprocessing was brought up in a few of the interviews carried out. Reprocessing is based on the idea that the uranium inside spent fuel is a very valuable resource which could be reprocessed and turned into something more useful. A member of the American Nuclear Society says: “There are so many conflicts in the world over resources, and it seems like a shame to take this very valuable and fairly rare resource, enriched uranium, and bury it away as waste.” The former nuclear engineering consultant that we spoke with feels that future generations will have the technology to extract the useful isotopes from spent nuclear fuel more efficiently and safely than they can today. He states that the longest lasting radioisotopes in spent nuclear fuel are plutonium and uranium that can be reprocessed and used. He feels that if we extract these useful isotopes from spent fuel we will decrease the amount of time that it is hazardous for by hundreds of years “The worst thing to do with plutonium is to store it, the best thing to do with plutonium is to fission it.”

F. The benefits of Regional Storage

This section will discuss the issues brought up by interviewees that related to the issue of regional storage. The issues brought up in the background research and the interviews carried out suggested that regional storage issues ran deeper than the scope of this report. However, we were able to gather data on the debate of regional storage versus on-site storage, including the problem of equity, or the fairness of burdening individuals with waste that others benefited from.

The issue of having a regional storage system as opposed to storing waste at a number of different sites was addressed directly in some of our interviews. A Maine Yankee CAP member said that regional storage would be good because it would lower the number of ISFSI sites in the country, thereby reducing the likelihood that USNRC regulators might accidently overlook aspects related to safety during cask inspections. The interviewee in this case is referring to neglect, which they felt was more likely to occur with more plants being open. The nuclear engineering consultant that we spoke with said that he believes waste should be moved to a regional storage site immediately where it can be stored before Yucca Mountain opens.

Others were against regional storage, or more specifically, the inequities associated with it. Equity in this sense refers to fair practices associated with interim storage of nuclear waste. Specifically, equity revolves around the issue of a site storing its waste in a town that does not benefit from the electricity produced. A member of the Citizens Awareness Network brought up the concern that if waste is allowed to move from one community to be stored in another, the burden of waste is simply being passed on. This individual lived in a town that had nuclear waste that needed to be stored, and stated that she did not think it was fair to pass the burden of nuclear waste storage onto another town that did not benefit from the electricity produced by the plant. A second individual, who was a member of the Utah Department of Environmental Quality, also expressed that the individuals who benefit from nuclear energy should be responsible for the waste they produce, rather than passing it on to someone else. This individual stated that Utah public officials are opposed to hosting private fuel storage sites, because the state of Utah has no nuclear reactors and creates no nuclear waste. She felt that storing waste which is produced in other states is unfair, because the state of Utah did not benefit from the power generation of the plant that produced the waste.

G. Demographical Data

We were able to find a variance in opinions with regards to the issues associated with the cost of storing spent fuel, how safe the waste is, how well it is secured, whether or not regional storage should be implemented, how well the public's view are represented, and whether or not waste should be reprocessed rather than sent to a long term storage site. We grouped these categories based on the groups we spoke with. Also, since a number of the individuals we spoke with were from Maine Yankee, we grouped what these individuals said.

We interviewed four different members of interest groups. These individuals put emphasis on the issues of security, cost, and public representation. These members tended to worry most about the overall security of dry casks in the event of a terrorist attack, ISFSI owners going bankrupt, and the lack of public representation in the current process of ISFSI licensing. The interest group members we contacted also seemed to find the NRC difficult to work with; saying that they needed to file suit to see action taken on their concerns.

Interest group members did not bring up the issue of reprocessing, and tended to avoid the technological safety issues. Their issues tended to be more social and political; calling for more efficient public representation, more sound security measures (like Hardened On-site Storage and increased security staff), and for the federal government to take care of the costs associated with interim storage.

We also interviewed three individuals who work or had worked for the government. All of these individuals said that they felt that the dry casks at interim sites are safe. Two of them felt that fuel should be moved from fuel pools to dry casks as soon as possible, while the third felt that fuel pools are a sufficiently safe and secure method for storing spent nuclear fuel. The two individuals who had concerns about storing fuel in fuel pools also expressed concerns about interim storage becoming a long-term option for storing waste. Two of the government representatives felt that the public is confident about how they are being represented by the NRC, while the other felt that the public is very frustrated with how the NRC responds to them. One individual expressed that they were against the regional storage of interim waste.

The next group that we dealt with was members of the general public. Both of these individuals said that they felt that dry casks are very safe and secure. However, they both raised concerns about what needs to be done with waste in the long-term, saying that interim storage is not ideal as a permanent storage option. Both of them say that from their observations, the public they deal with is well represented in the planning and relicensing process.

The last group that we spoke with was plant representatives and consultants. We spoke with two individuals of this demographic, who had very similar concerns and opinions. First of all, they both said that they thought that dry casks are safe and secure. Also, they are both confident with how the public's concerns are heard and addressed. However, they are both concerned with finding a permanent storage site because interim storage is not a viable option for long-term.

We spoke with four different individuals involved in the decommissioning of the Maine Yankee plant. They all felt that the public was well represented, and say that the CAP program has been very helpful in addressing citizens' concerns. The three individuals who commented on fuel pools say that they feel fuel pools are safe, but that that dry casks are safer and that spent fuel should be moved to dry casks as soon as it is sufficiently cooled. They were all content with interim storage; however they felt that it is not a good option for storing waste for a long time, and say that it is important to develop a better storage method for the long term. Overall, the members of the Maine Yankee CAP were not concerned with how interim storage is being handled, but feel that a better long-term option needs to be developed.

Table 5 shows a visual representation of the demographic data analyzed above. The table is organized by how each individual is affiliated with interim storage, as other a member of an interest group, the general public, a plant representative or a government employee. The five dimensions are shown, and are color coded to indicate how positively or negatively the individual feels about that dimension. A red bar indicates that the individual had concerns about that issue, a green bar indicates that the individual was not concerned, and a grey bar indicates that the individual did not address the concern in their interview, black indicates that it is sometimes an issue.

Table 5. Demographic Data Graphical Results

Affiliation	Nearest Power Plant	Cost	Safety	Security	Public Representation	Reprocessing
Interest Group	Wisconsin					
Interest Group	Diablo Canyon					
Interest Group	Washington					
Interest Group	Yankee Rowe					
Public	Maine Yankee					
Public	Unknown					
Plant Retired	Yankee Rowe					
Plant	Maine Yankee					
Government	None					
Government Retired	Maine Yankee					
Government	NRC					

The Community Advisory Panel (CAP) is a community advisory panel at the Maine Yankee nuclear power plant site. The Maine Yankee CAP was established in order to increase open communication between the public and the facilitators of the Maine Yankee nuclear power plant during the decommissioning process of the Maine Yankee. Members on the committee were selected based on their involvement with the power plant and on what group each person could represent.

H. Summary

In this chapter, we were able to show how members of different groups felt on various issues. This data was necessary for further analysis. In the next chapter, we analyze this data so that we could come up with findings and conclusions about the topic of interim storage.

5 Findings

Analysis of the data collected led to seven categories of findings on the issue of interim nuclear waste storage; safety, cost, security, public representation, overall support of interim storage, reprocessing, and issues associated with regional storage.

A. Safety

The radioactivity emitted from spent nuclear fuel is capable of causing cell death or cell alteration (Bertell, 1986). Dry casks are used to shield this harmful radiation, which led our group to assume that the safety of dry cask storage was a possible issue that would be raised by individuals on the topic of interim storage of nuclear waste. Therefore, we asked our interviewees questions about how safe they felt dry cask storage of nuclear waste was. Their responses and our own background research led to the following finding.

Finding 1: The ability of dry casks to store waste safely is not a significant concern.

Ten out of the eleven individuals interviewed did not say that the safety of dry cask storage units was an issue of concern to them. When one safety-related concern was expressed, the individual did feel that storage in casks was safer than fuel pool storage.

The safety-related issue expressed was that dry cask tip-overs due to earthquakes could lead to ruptures, and radiation could be released from the cask. However, as stated in the background of this report, dry casks are designed to ensure adequate passive heat removal and radiation shielding for regular operations as well as in the event of a tip over, and some protection against external assaults (NAS, 2005). Also, dry casks go through drop testing to ensure that they can withstand much greater impacts than that which would be caused by an earthquake related tip-over (NRC, 2005). This information suggests that the person's concern is not valid; because it suggests that the casks ability to shield radiation would not be compromised in the event of an earthquake.

The background information gathered in this report suggests that the process involved in loading dry casks and the safety of the final cask have been evaluated and are considered safe by regulators (NRC, 2005). The loading of the dry cask canisters is done underwater in fuel pools to shield the radiation from the workers and surrounding environment (NRC, 2005). The canisters are then welded and placed into a large concrete container (VirtualNuclear, 2008). The canister and container together make up what we call a dry cask, and are designed to shield the heat and radiation of the waste from the external environment.

B. Cost

Cost is important to consider for interim storage strategies because of the large amounts of capital needed to license, fill, and erect a dry cask storage unit. According to our sources, the total upfront costs for a dry cask storage unit are between $8 and $12-million (Zorpette, 2001). After conducting our interviews we found that the issue of cost was raised in the context of who should pay for the dry cask storage units, and who should be responsible for the site in the long term, not in regard to the total costs of the systems.

Finding 2A: Who should be responsible for paying for dry cask storage is disputed.

Interviewees felt that cost was an issue for dry cask storage, because the company that owns the plant has to pay for the casks. This was stated as an issue because the interviewees felt the companies that own the plants pass on the bill to the ratepayers by increasing the price of electricity. Interviewees expressed that they felt the federal government was responsible for this problem, because they were unable to open the national repository as initially planned. Some individuals went as far as to say that the government should pay for the casks in full.

Finding 2B: The financial ability of ISFSI owners to maintain dry cask units may not be sufficient if the company goes out of business.

Some of the individuals interviewed expressed concerns about the ability of the company in charge of the ISFSI to maintain the facility for large amounts of time. These individuals stated that even large companies are at risk of bankruptcy, especially over the possible duration of these dry cask storage facilities, which could be in excess of 20 years. These interviewees were concerned about who would be responsible for stepping-in and maintaining the waste in such a scenario.

This is a major concern to many individuals at the moment. It has been speculated that if a site owner were to go bankrupt the surrounding community would be left in charge of the costs of upkeep. However, we could find nothing written into law that specifies who is responsible for the waste in the event of an owner bankruptcy. This seems to validate the concerns of the individuals interviewed; no public plan seems to be in place.

C. Security

We felt that security of dry cask units would be an issue to the individuals interviewed due to the fact that dry cask storage units were not designed to withstand terrorist attacks like those of September 11th, 2001 (NAS, 2005). This information suggests that some individuals might question the dry casks ability to withstand an impact from a large aircraft. However, our study found that individuals were not concerned specifically with dry cask storage as a method for nuclear waste storage, but rather, they were concerned with how the casks are arranged and protected. Some individuals felt that dry cask storage was very safe and that cooled waste should be moved to casks immediately to decrease security risks.

Finding 3: Security of dry casks is important to maintain, but there is very little concern about terrorist attacks on dry casks.

The individuals interviewed felt that dry cask storage is a secure method for storing nuclear waste. Many expressed that they were not concerned with the security of the casks, because they felt that they were robust enough to keep the waste safe from terrorist attacks. However, the individuals interviewed did feel that maintaining adequate levels of security is necessary.

Dry casks are very robust containers that are designed to store radioactive waste safely and securely. Initial research suggests that a large airplane impact would result in damage to the cask, but that large amounts of radiation would not be released (NAS, 2005).

Finding 3A: Waste stored in fuel pools is more vulnerable to terrorist attacks than fuel stored in dry cask units.

Some individuals interviewed felt that dry casks were sufficient for secure waste storage, and encouraged waste in fuel pools to be moved to dry cask storage immediately; to reduce the overall security risk of operating power plants. These individuals felt that waste stored in fuel pools was much more vulnerable to terrorist attacks than fuel stored in dry cask units, and that dry cask storage was the only available storage method that was acceptably secure for storing spent nuclear fuel for interim time frames.

This finding is supported by The National Academy of Sciences report on the safety and security of spent nuclear fuel released in 2004, which suggests that plant-specific vulnerability analyses carried out by the NRC might determine that earlier movements of spent fuel from fuel pools to dry casks might reduce the potential consequences of a terrorist attack (NAS, 2005). However, the NRC still maintains that fuel pool storage of spent nuclear fuel is sufficiently safe (Ward, 2003).

Finding 3B: Some individuals call for hardened on-site storage to increase the security of spent fuel to acceptable levels.

Other individuals thought that the casks were secure, but wanted storage facilities hardened, via earthen berms or protective bunkers, to increase the security against planned attacks. Hardened storage is a form of nuclear waste storage which is intended to be safer and more secure than traditional interim storage options, which leave dry casks exposed to view. While dry casks are very secure and robust, and can absorb large impacts without rupturing, they may not be capable of withstanding a determined, concentrated attack (Thompson, 2003). These casks may be hardened by surrounding them with layers of concrete, steel, gravel and other materials which make them even more durable. Hardened storage casks are more likely than traditional dry casks to withstand a highly focused attack such as an anti-tank missile (Thompson, 2003).

The individuals interviewed did not state that hardened onsite storage was imperative, but did want to see facilities hardened to remove the casks from sight in order to increase security. A Nuclear Regulatory Commission member that was interviewed stated that dry cask units were sufficiently safe and that hardened onsite storage was useful for removing line of sight from threats, but was not a necessary security measure.

D. Public participation in decision making about on-site interim storage

The process of ISFSI licensing is not very open to public concerns. The public is only guaranteed one opportunity to comment on the ISFSI and its location. This opportunity is called the notice of availability for public comments, and comes after the submission of the Environmental Assessment and the Finding of No Significant Impact (USNRC, May 2007). These comments can be mailed to the USNRC, but do not require action. If no significant issues are found, either with the location of the ISFSI or the casks to be used, in the five to six months following the release of the EA and FONSI, the dry cask proposal is licensed by the NRC and construction can begin (USNRC, May 2007). This process does not require the plant or the NRC to allow in person opportunities for comment during or after the licensing. This information suggested to our group that many of the individuals interviewed would feel that the public was not properly represented in the current system. However, we found that only in about half of the interviews this was the case. In the other half of the interviews, the individuals felt that the public was represented very well in the current system.

Finding 4: Views on the level and quality of public involvement in interim storage planning and licensing were varied.

About half of the individuals interviewed stated that the public did not have proper opportunities to make comments and ask questions during the process of ISFSI licensing and approval. These individuals stated that this lack of involvement frustrated the public, and did not take their views into account properly. Some of these individuals stated that the only way to ensure their views were considered was to sue the Nuclear Regulatory Commission.

One individual stated that the level of public involvement in the issue depended on the effort put forth by the local nuclear power plant to open up for public comment.

Other individuals felt that the process was sufficient. Many of these individuals were Maine Yankee CAP members, who felt that their committee was able to communicate the proper information to the public and bring the proper public concerns to the attention of the plant. One individual interviewed felt that the public was sufficiently involved, and stated that the NRC was putting forth a significant effort to involve the public in this process.

E. Overall Support for Interim Storage

Some of the individuals interviewed fell within the same demographic group. This section seeks to compare the comments of individuals within each demographic; in order to determine that group's overall support for interim storage.

Finding 5A: Individuals identifying themselves as members of interest groups were among the least positive supporters of interim storage.

The analysis of this demographic group, found in the results chapter, shows that members of interest groups raised the most issues about interim storage of nuclear waste. The issues raised were primarily social and political ones, and were based around security, cost, and public representation.

Finding 5B: The only issue considered unanimously among individuals identifying themselves as members of the government was safety.

There was very little correlation among the issues that members of the government brought up about dry cask storage. The analysis of this demographic group can be found in Table 5, which clearly shows that the members of the government were only able to agree that dry cask storage units are safe. This level of disagreement shows that even within the government there are varied views about the issues related to dry cask storage of spent nuclear fuel.

Finding 5C: Members of the general public that were interviewed in this report felt that the public was properly represented in the ISFSI licensing process.

The members of the general public interviewed in this report felt that they, and the other members of their demographic group, were properly represented in the current licensing system. This is an unexpected finding because about half of the individuals interviewed felt that the general public was not properly represented in the current system. This result may be an artifact of interviewing only two members of the public in this project.

Finding 5D: Plant representatives were most concerned with finding a long-term solution to the waste storage issue.

The plant representatives interviewed were both very knowledgeable about interim storage of nuclear waste. This finding is interesting, because these individuals, who had large amounts of knowledge about dry casks, were very concerned with bringing waste to a more long term solution. This finding, like the last, may be an artifact of interviewing only two members of the public in this project.

Finding 5E: Individuals involved in the Maine Yankee CAP were among the most positive supporters of dry cask storage.

The Maine Yankee CAP demographic was analyzed in the results section of this report and showed that CAP members were among the most positive supporters of interim storage of nuclear waste in dry casks. Four individuals were interviewed from the Maine Yankee CAP, they felt that the casks were sufficient for their purpose, and raised very few concerns.

F. Reprocessing

Reprocessing of spent nuclear fuel is currently an issue of national debate. The early interviews conducted by the group did not ask questions about reprocessing, therefore, only three of the individuals interviewed commented on the issue of reprocessing. All three of these individuals suggested that they would, now or in the future, like nuclear waste to be reprocessed, in order to make the best use of the radioactive plutonium inside. The background information gathered in this report suggests that it would not be possible to begin reprocessing waste in the United States. This is because the product obtained from the reprocessing is not only useful for nuclear fuel, but also for making nuclear weapons (Andrews, 2006). This weapons grade material was, as stated in the background, limited by the government in order to restrict the proliferation of nuclear weapons (Andrews, 2006).

Finding 6: Reprocessing of nuclear waste is an issue of debate that should not be linked to dry cask storage of nuclear waste.

An individual interviewed suggested that nuclear waste should be stored in dry casks for interim time periods, because he felt that reprocessing technology would advance in the next few decades to safe and acceptable levels, at which time the waste could be retrieved from the casks and reprocessed. This idea is refuted by the background material gathered in this report. This is because the nuclear isotopes extracted by the reprocessing are weapons grade (Andrews, 2006). The United States policy, since the end of the Cold War, has been to limit the proliferation of nuclear weapons (Andrews, 2006).

Also, these issues should not be linked because, even if policy did allow fuel to be reprocessed, the need for dry cask storage would not be eliminated. Dry casks would still be needed to store the spent nuclear fuel that could no longer be contained in fuel pools at operating plants, until a reprocessing plant is available to reprocess it. Also, dry casks would be needed to transport the spent nuclear fuel to the reprocessing plant. These points seem to suggest that supporting dry casks on the issue that they might aid the reprocessing of fuel is not a valid reason to support interim storage.

G. Issues Associated with Regional Storage

Regional Storage refers to ISFSI sites that all the waste in one region would be transported to. These sites have advantages and disadvantages which were found in the background data and were brought up in the interviews.

Finding 7: The number of on-site interim storage locations should not affect the ability of regulators to carry out proper cask inspections, because of the USNRC inspection standards that are in place.

Some individuals called for regional storage because they felt it was a better solution to the dry cask storage problem. One of these individuals stated that they wanted regional storage facilities, because they would lower the risk of regulators overlooking aspects related to safety during cask inspections. This individual felt that if many ISFSI sites are open around the country, the USNRC have trouble inspecting each site thoroughly, and over time that some sites might become neglected. The individual felt that this neglect could increase the safety and security risks associated with interim storage. This issue is refuted by the existence of the USNRC, which enforces security standards that all sites are required to meet (USNRC, 2004).

Finding 7B: The equitability of interim storage of nuclear waste at regional facilities is questionable.

Other individuals were against regional storage of nuclear waste. These individuals raised the contention that it was not equitable to move waste produced in one area to another. These individuals felt that the people who benefitted from the power created from the nuclear plant should also be responsible for bearing the burden of the waste produced. One individual, from Utah, stated that since Utah does not produce waste, it is the last place waste should be brought to.

H. Summary

Analysis of the data collected led to seven categories of findings on the issue of interim nuclear waste storage; safety, cost, security, public representation, overall support of interim storage, reprocessing, and issues associated with regional storage. These findings help clarify the issues at hand. The following section contains policy and further study recommendations based on these findings.

6 Recommendations

Two types of recommendations are made in this report. The first type deals with policy issues, in an attempt to remedy the most significant concerns about interim storage of nuclear waste. The second type of recommendation deals with topics that we would recommend for further study on the issue of interim storage of nuclear waste.

I. Policy Recommendations

The recommendations in this section are addressed to actions that we suggest the federal government should take or might look into taking concerning dry cask storage of nuclear waste.

Recommendation: The federal government should consider creating a new tax on power generated from nuclear reactors that will go toward an account that will fund interim storage of nuclear waste.

This sort of funding for dry cask storage seems to make more sense than the current system; in that the interim waste storage would be paid for while electricity is still being produced. This tax would be issued on top of other fees embedded in the cost of nuclear generated power and would pay for interim storage casks that will need to be built between now and the 2017 expected opening date for Yucca Mountain (United States Senate, 2006). The revenue generated would only be used for the erection of dry cask storage units. This type of fund might encourage plant owners to build dry cask storage units as soon as their waste is cooled. This would keep the waste in fuel pools to minimum levels, which has been suggested as a measure that might lower the security risk associated with each individual plant (NAS, 2005).

Recommendation: The federal government should, if they have not already, formulate a plan of action for the scenario of an ISFSI owner bankruptcy.

A written plan of action would be useful in this case in order for the government to be prepared in the event of an ISFSI owner bankruptcy. The possibility of bankruptcy is relevant to the companies involved in this scenario because of the long length of time that the facility could be needed. This written plan of action would detail what organization is responsible for keeping the site safe and secure and where it will get funding from.

Recommendation: The federal government should create definite standards for nuclear waste storage security.

If hardened on-site storage is necessary in order for a dry cask to survive security risks, such as a large plane crash, then the USNRC should consider the chances of such an attack and determine whether hardened on-site storage is necessary. This recommendation comes from the fact that none of the plants in the United States are out of the range of aircraft flight, and therefore, are not out of the range of terrorist attacks related to crashing planes.

II. Further Study Recommendations

The recommendations in this section suggest further areas of study related to dry cask storage of nuclear waste. These further areas of study represent gaps that we were unable to cover in our report.

Recommendation: The federal government should investigate the success of the Maine Yankee Community Advisory Panel in order to determine the usefulness of such groups in helping plant operators to communicate with the public during the decommissioning process.

This recommendation comes from the success of the Maine Yankee CAP. The members of this group felt very strongly that they were able to help inform the public about the ISFSI that was being set up during the Maine Yankee power plant decommissioning. The community advisory panel was able to bridge the gap between the power plant operators and the public in the area. The CAP members felt that they were able to increase the public's level of involvement pertaining to the ISFSI facility. Our research suggests that panels like this elsewhere could have the same effect. If this is the case then the NRC might find it useful to help set up/require plants to set up these types of panels during the decommissioning process.

We suggest further research be done to determine the usefulness of groups like the Maine Yankee CAP for aiding communication between nuclear power plants going through the decommissioning process, and the public surrounding them. This research might survey individuals living near the decommissioned Maine Yankee site, and individuals around other decommissioned plants that did not have a community advisory panel during decommissioning. Determining the usefulness of such a group for communicating with the public in the area would be useful information for the NRC if they were considering making these groups commonplace.

Setting up groups like the Maine Yankee CAP at other plants undergoing decommissioning might help alleviate the public communication issues that were referred to by the individuals interviewed in this report. This would benefit the public, in that they would have their opinions heard, and the plant, in that they would have a chance to communicate what they are doing and the level of safety involved in dry cask storage.

Recommendation: A more detailed study of regional storage options should be completed.

Regional storage of nuclear waste is an issue that was not covered in proper depth in this report. We suggest that another report might be done solely on regional storage of nuclear waste to properly weigh the issues that relate to it. Such issues include: equity, transportation, security, safety and cost.

The issue of equity of regional storage of nuclear waste is questionable, and tough to resolve. We feel that further investigation into this issue would be useful to determine the facts behind the arguments brought up. Such facts might include: the amount of revenue brought in by states that would allow private fuel storage, the amount of space taken up by such a facility, and the security and safety risks imposed on public surrounding the facility.

Recommendation: A further study should investigate how members of the public from various locations feel they are represented in the ISFSI licensing process.

Finding 5C in this report stated that the members of the public interviewed felt that the general public as a demographic group was properly represented in the ISFSI licensing process. This is interesting because many of the other individuals interviewed felt that the general public was not represented properly. We recommend that another report might be done with a larger sample of individuals who identify themselves as members of the general public. This report might be useful for determining how the public feels that they are represented in the ISFSI licensing procedure.

Recommendation: A further study should interview more plant representatives in order to determine their thoughts on dry cask storage for an interim time frame.

Our sample group found that plant representatives were concerned with finding a long term solution to the nuclear waste storage problem. We recommend a further study that takes into account the views of a large number of plant representatives from different plants across the United States. This larger sample group might be useful in determining the thoughts these individuals have on long term solutions to nuclear waste storage.

7 Conclusions

The goal of this project was to determine what social issues are intertwined with the issue of interim storage of nuclear waste. Information was gathered from various sources: government websites, independent reports, and interviews with individuals from the government, the public, interest groups, and plant representatives/consultants. From the information gathered we generated fifteen findings.

Summary of Findings and Recommendations

This report presents findings in seven categories: safety, cost, security, public representation, overall support of interim storage, reprocessing, and issues associated with regional storage. Recommendations were made based upon these findings on the issues of security, public representation, and cost.

The first finding was that safety was not a major issue of concern for the individuals interviewed. This finding is backed up by the information gathered during the report writing process, which stated that dry cask storage of spent nuclear fuel is sufficiently safe for shielding heat and radiation from the external environment.

The second set of findings was that people are concerned about who will pay for the dry cask storage unit and that the companies that own the ISFSI sites might be outlived by the waste storage site. To address the first finding we recommended that the federal government might consider creating a tax on nuclear power that goes toward an account that will fund interim storage of nuclear waste. This type of tax ensures that the waste storage is paid for while the electricity is being produced, thus making sure that the individuals that benefit from the power pay for the disposal of the waste. To address the second finding we recommended that the government should create a plan of action pertaining to the situation of bankruptcy of a plant owner. Having this plan of action ready would ensure that the waste will be taken care of properly in the event of a sudden plant owner bankruptcy.

The third set of findings pertained to the issue of security. The first finding stated that the necessary level of security for dry casks was an issue of debate. The second finding was related to the first and stated that some individuals feel that fuel pools are less secure than dry casks, and that waste should be moved from fuel pools to dry casks as soon as it is cooled. The third finding was also related to the first, and stated that some individuals feel that hardening dry cask locations is the best way to ensure that the waste is properly secure. Our recommendation on this topic was that the federal government should create definite standards on how waste should be stored to maximize security.

The fourth finding was that the level of perceived public involvement was variable among our sample of interviewees. We noted that the Maine Yankee CAP members were the most confident in the representation of the public in their area. Therefore, we recommended that the federal government might investigate this success and determine the usefulness of such groups. If these groups are found to be useful, the federal government might set up groups of this nature at other plants or require other plants to set up said groups.

The fifth set of findings pertained to the overall support different demographic groups had for interim storage. The demographic groups analyzed were: members of interest groups, members of the government, members of the public, plant representatives, and the Maine Yankee CAP. We found that the members of interest groups were the least positive supporters of interim storage. Members of the government were not able to agree on any of the issues presented except for security. Members of the public felt that the public was well represented in the current ISFSI licensing process. Plant representatives wanted to see long term storage options become available. Maine Yankee CAP members were the demographic group interviewed with the most positive views on the topic of dry cask storage. We recommended a future study be done with a larger sample group of the public, asking about their opinions on the level of public involvement in ISFSI licensing. We recommended future studies be done with larger sample groups of plant representatives as well, particularly asking these individuals how they felt about long term nuclear waste storage methods.

The sixth finding had to do with reprocessing of spent nuclear fuel. We found that the issues of reprocessing and interim storage should not be linked. This is because the political issues at the heart of the reprocessing dilemma have nothing to do with interim storage of nuclear waste. Specifically, storing the waste for a few years in casks will not open an opportunity for reprocessing, by allowing the technology time to develop, because the radioisotopes extracted from spent nuclear fuel are weapons grade, production of which is against United States policy.

The seventh set of findings had to do with the issue of regional storage. We found that the argument that regional storage would decrease the chance of regulators overlooking aspects related to safety during cask inspections was not valid. We also found that the equity of regional storage facilities was questionable. We recommended that further research be done focusing on the issue of regional storage. We also recommended that further research be done focusing on weighing the facts surrounding the equity of regional storage.

Report Summary

This report considered the social issues associated with interim storage of spent nuclear fuel. It identified which issues were most important and validated these issues. Interim storage issues are important to consider because spent nuclear fuel is a long lasting material, and currently has no final resting place. The issues involved with storing the waste until a final solution can be found, must be resolved in order to avoid problems such as fuel pools filled to levels that are not secure. At the same time, we must continue to consider the things that are important to us. Rushing to solve this problem is not the solution, we must work together to find out which solutions are the safest, most secure, most cost effective, and most fair.

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