UNNECESSARY RISK

The Case for Retiring Oyster Creek Nuclear Power Plant

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Executive Summary

New Jersey is home to the nation's oldest operating nuclear power plant, Oyster Creek Nuclear Generating Station. Although Oyster Creek's operating license expires in 2009, its owners may seek a license extension by April 2004 from the federal government to allow the plant to continue operating, perhaps for another twenty or thirty years.

Given the risks associated with continued generation of radioactive waste, escalating potential for accidents at aging reactors, the vulnerability of the plant as a terrorist target, and our ability to replace the power generated by the plant, Oyster Creek should not be relicensed.

Oyster Creek threatens public health and safety in New Jersey in the following ways:

Oyster Creek generates highly radioactive waste, which is currently building up on site:

- It is very probable under any scenario that highly radioactive waste generated by Oyster Creek will be stranded permanently in New Jersey. Even if current plans for establishing a Federal Waste Repository at Yucca Mountain move forward on schedule, that facility would reach maximum capacity before more than 145 metric tons of nuclear waste generated under the current license were offloaded from Oyster Creek, stranding the waste in Ocean County.

- If Oyster Creek were relicensed to operate another 20 years, it would generate an additional 338 cubic meters of high-level radioactive waste, weighing over 1.4 million pounds, with no clear disposal option outside of the state.

Oyster Creek's fuel ponds are particularly vulnerable:

- Currently more than 2500 assemblies holding highly radioactive spent fuel are stored in cooling ponds 400 feet from Route 9. These ponds, located on the top floor of the five-story reactor building, have no significant reinforcement structures to prevent damage from an external hazard, such as an intentional attack on the facility.

The plant routinely exposes the surrounding environment to radioactive emissions:

- In 2000 (the latest year for which nationwide data is available) Oyster Creek had the highest level of radioactive iodine air emissions of any boiling water reactor in the country.

Due to the plant's age, the risk of a serious accident at the plant is increasing:

- Oyster Creek is the oldest operating nuclear reactor in the United States, and next year will set a new record for the longest time any reactor has operated in the nation. With inadequate federal oversight, severe age-related degradation may be occurring undiscovered, heightening the risk of a serious accident.

- In the event of an accidental pressure buildup at Oyster Creek, there is a high likelihood of deliberate release of radioactivity directly into the environment in an effort to avoid a core meltdown. This deliberate release would be necessary due to a structurally deficient containment system that would not meet licensing standards if the plant were built today.

New Jersey need not depend on Oyster Creek to meet its electricity demand:

- Oyster Creek provides less than 1% of current generating capacity in our regional electricity grid.

- New natural gas generation planned for New Jersey over the next three years will provide electricity generation capacity greater than that of Oyster Creek.

- Developing the state's potential for renewable energy and energy efficiency measures can meet projected increases in state demand for electricity in 2009 and beyond.

By advocating to ensure Oyster Creek is closed in 2009, as originally planned, and focusing our resources on developing renewable energy production and conservation programs in the state, New Jersey can do more than meet electricity demand–we can protect public health, prevent environmental degradation, and decrease our vulnerability to terrorist attack, while investing in technology that can help New Jersey develop its leadership in the high tech economy.

Introduction

In the summer of 1969, one month after Neil Armstrong became the first person to walk on the moon, Jersey Central Power & Light finished building Oyster Creek Nuclear Generating Station in Lacey Township, New Jersey.

That winter, Oyster Creek became the first large-scale nuclear power reactor to begin commercial operation in the United States, licensed to operate for a forty-year lifetime. Now, along with a very similar plant at Nine Mile Point in Oswego, New York, Oyster Creek is entering its 34th year, setting a new record for the longest time any commercial reactor has remained in operation in the United States.

Oyster Creek's routine operation, like that of all nuclear power plants, poses real risks to public health and the environment.[1] More than three decades after the federal government first encouraged the commercial development of nuclear power, no safe storage solution has been found for the lethal radioactive wastes that are its inevitable byproduct. These wastes continue to build up in vulnerable cooling ponds literally a stone's throw from Route 9.

Furthermore, as Oyster Creek ages, another set of risks is growing. Recent near-misses at aging reactors such as the severe corrosion discovered at First Energy's Davis Besse plant in Toledo, Ohio clearly demonstrate that dangerous structural weakness in older plants may not be discovered in routine inspections. The ever-present risk of a catastrophic accident at Oyster Creek looms larger every day.

Five years ago, no one would have dreamed of proposing that the government gamble on our safety by relicensing Oyster Creek to operate for longer than the originally anticipated forty-year lifetime.[2] Even if age-related degradation were not a concern, Oyster Creek would have been considered a technological dinosaur, built under design standards and specifications that do not meet current licensing requirements for a new plant.

In fact, five years ago the plant's owner announced plans to retire Oyster Creek early, anticipating that it would not be economically competitive to continue operating the plant in New Jersey's soon-to-be deregulated electricity markets.

Then the owner found an unexpected buyer: Amergen, a joint partnership of British Energy and Exelon, came to the "rescue," purchasing Oyster Creek at the bargain basement price of $10 million. Oyster Creek joined British Energy's growing collection of nuclear reactors, including Three Mile Island-1 reactor in Pennsylvania, the Nine Mile Point-1 and -2 reactors in New York, and the Clinton reactor in Illinois.

As this report goes to print, Oyster Creek is on the market once more. British Energy, who owns a fifty percent share in the plant, is reeling under new economic pressures resulting from uncompetitive performance of its nuclear facilities in Britain's recently deregulated energy markets. No longer fiscally sound, British Energy must sell off its North American assets as part of a debt restructuring agreement with the British Government.

Any prospective buyer is likely to apply to the federal Nuclear Regulatory Commission for a license extension to allow Oyster Creek to operate for twenty, or even forty years, beyond its designed lifetime. Given NRC's track record to date, it is reasonable to assume that such an application would be rubberstamped, without due consideration of the health and safety consequences of a plant's continued operation.

Nevertheless, the upcoming sale and license transfer of Oyster Creek, as well as any application for a license extension, provide a real opportunity for state and local officials to intervene in the process and demand that the health and safety of New Jersey citizens are put above the private interests of the plant owners. While local policy leaders and the public do not have the ultimate decision-making authority in the relicensing and oversight of nuclear facilities, their position on continued operation of a nuclear facility in their backyards does matter.

New Jersey officials must demand an open and public process that scrutinizes the claims made by the plant owners and which pierces the protective veil of secrecy created by the NRC. Without such careful scrutiny, there is every reason to believe that important issues affecting the public welfare and safety will be swept under the rug.

Already, the New Jersey Department of Environmental Protection has intervened once in Oyster Creek's oversight in an effort to protect the public interest. In August, 2002, the DEP publicly intervened with the NRC when Amergen requested an administrative exemption. This exemption would have shortened the time period in which regulators and the public could scrutinize Amergen's application for a license extension, by allowing Amergen to delay submitting its application beyond the current April 2004 deadline.

As this report documents, the retirement of Oyster Creek would remove a considerable threat to public health and the environment, and need not have a significant impact on the reliability of the state's electricity grid.

With persistent and vigilant state leadership, New Jersey can ensure Oyster Creek is permanently retired in 2009, a critical step in charting a new course toward a clean, reliable, and safe energy future, setting a precedent both for the state and the nation.

Section I: Nuclear Power Production Creates Unsolvable Long-Term Problems

This report shows that Oyster Creek's continued operation poses a number of risks to New Jersey's population and the environment. Nuclear power generation at Oyster Creek:

- creates long-lived, highly radioactive waste;
- produces large quantities of low-level radiation that has been linked to cancer, genetic defects, and immune deficiencies;
- depends on environmentally destructive uranium mining; and
- concentrates large amounts of energy in one location, contributing to uniquely catastrophic accident scenarios.

Perhaps foremost among these risks is the constant production of radioactive wastes that are among the most carcinogenic known to man. No technology has been developed to ensure these long-lived, bioaccumulative wastes remain isolated from living creatures for the tens of thousands of years it will take for them to decay to negligible levels of radioactivity. For this reason, nuclear power, whether generated by Oyster Creek or any other of the nation's 103 nuclear plants, is intrinsically dangerous.

BACKGROUND

Nuclear Fission Is an Inherently Radioactive Process

Nuclear power plants generate more than just electricity. The same process that releases power in a nuclear plant inevitably generates large amounts of radioactive byproducts. According to the Department of Energy, commercial nuclear reactors have produced more than 95% of man-made radioactivity ever created in the United States.[3] Exposure to radiation can and does occur in every step of the nuclear fuel cycle, from the mining and enrichment of uranium ore to the reaction in the core of a nuclear power plant and the disposal of these wastes. As radioactive byproducts build up at the nation's 103 operating nuclear power plants, the challenges and problems posed by the continued operation of these plants become increasingly urgent.

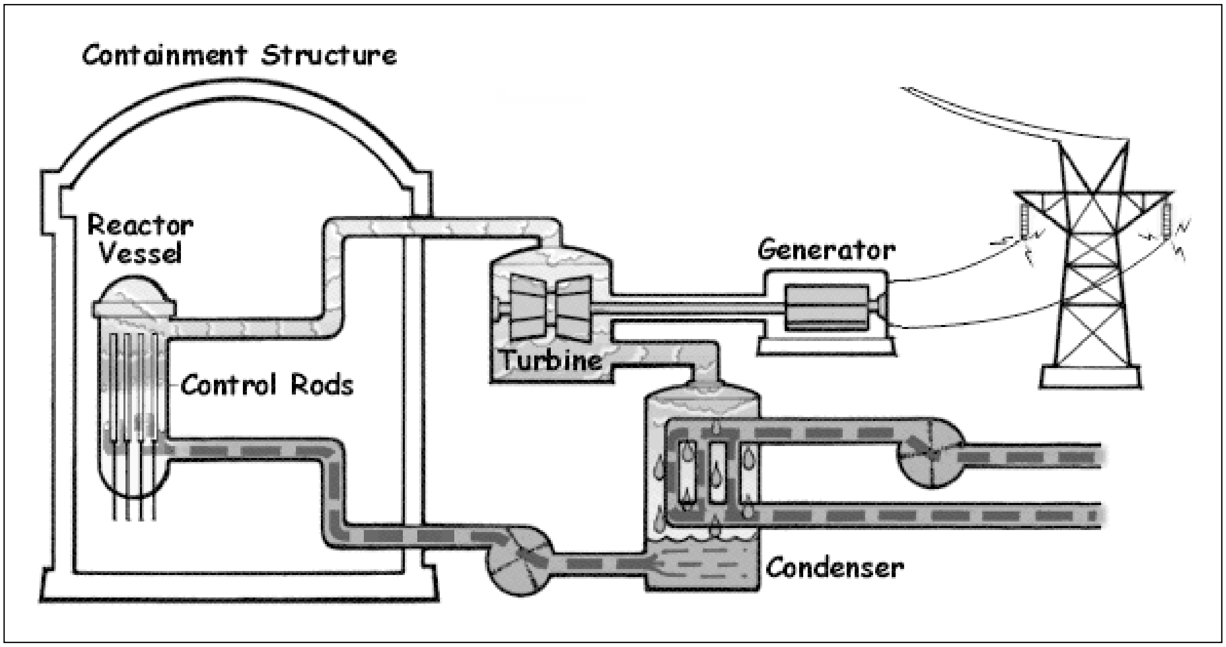
Figure 1 (see next page) is a schematic diagram of a boiling water reactor. The nuclear core for the boiling water reactor at Oyster Creek contains 560 fuel assemblies containing about 70 tons of uranium.[4] In a boiling water reactor, each fuel assembly typically is made up of hundreds of fuel rods, long metal cylinders which contain hundreds of ceramic pellets of uranium dioxide, the nuclear fuel.

In the reactor core, neutrons collide with heavy, unstable uranium atoms, splitting them into lighter elements such as krypton. When the uranium atom splits, it releases large amounts of energy, as well as additional neutrons. The uranium atoms decay into any of 80 different kinds of radioactive fission fragments, which in turn may decay into 300 different radioactive chemicals.[5]

The neutrons released in this first fission in turn collide with other atoms, causing a chain reaction. In a nuclear bomb, this chain reaction is allowed to continue essentially unchecked. In a nuclear power plant, however, the reaction is moderated by control rods that absorb neutrons, slowing down the chain reaction and limiting the amount of energy released. This energy heats the water in the core of the reactor to about 520 F°. Heated water becomes steam, which spins turbines that are connected to electricity-producing generators. Then cold water is pumped in to cool the steam, which condenses into water before it is fed back into the reactor core.

Radioactivity is a measure of how unstable an atom is–how quickly it decays into other elements, releasing neutrons. Since the fission process depends on the decay of heavy, unstable uranium atoms to release energy, the process itself is inherently radioactive.

Figure 1. Diagram of a Boiling Water Nuclear Reactor Plant[6]



Scientists use several different units to measure radioactivity and its impact on living beings. Radioactivity itself is measured in curies. One curie is equivalent to 37 billion disintegrations or radioactive emissions per second.

At any given time, the average operating nuclear power reactor has about 16 billion curies at its core, which is equivalent to the long-lived radioactivity of at least 1,000 Hiroshima bombs.[7] In comparison, a large-sized medical center with as many as 1,000 laboratories in which radioactive materials are used has a combined inventory of about 2 curies.

The Health Effects of Radiation

In addition to splitting the nucleus of an atom, radiation can break the bonds between atoms. When this happens within cells of living organisms, it can lead to direct cell death, the inability of the cell to function, or the uncontrolled proliferation of the cell (leading to cancer). When it occurs inside a reproductive organ, it can lead to hereditary or genetic affects that are apparent in the offspring of the organism.

Every dose of radiation administered to a large population, no matter how small it may be, will cause a corresponding increase in the numbers of cancers, genetic defects in offspring and other diseases. If the radiation dose is cut in half, the increase in the number of people dying of cancer or having defective children will also be cut in half, but the degree of damage to each affected individual is undiminished.

Biological damage resulting from radiation absorption is measured in rems. Since the rem is a fairly large unit, radiation exposure is usually recorded in thousandths of a rem - or millirem. Once the dose has been measured in terms of rem, it can be compared to other doses, added to other doses, or used in risk comparisons regarding non-radiation risks.

There is no "safe" level of radiation exposure. Lowering the dose reduces the number of people who will be affected, but not the severity of the medical consequences. Nevertheless, in an attempt to protect public health, the U.S. EPA has established a dose limit of 25 millirem for the amount of radiation to which individuals living within two miles of a nuclear plant may be exposed. This limit is 250 times greater than the 0.1 mrem limit proposed by a new European Committee on Radiation Risk study to better protect individuals in the public.[8]

Direct exposure to high-level radiation from fuel in the core of a nuclear reactor delivers a lethal dose of radiation within seconds. Exposure to radiation can also be measured in rads, which measure the amount of energy deposited by radiation per unit of mass.[9] While exposure to only 450 rads can kill fifty percent of the people exposed to it, a single irradiated fuel rod exposed to the air could release approximately 10,000 rads or more each hour. For this reason, irradiated fuel rods are always surrounded by liquid coolant to help shield the radiation.[10]

Even low-level radiation damages tissues, cells, DNA and other vital molecules. Health effects of low-level radiation may not be evident for thirty years or more after the exposure, and some debate exists about how to best extrapolate the effects of low-level radiation from studies involving high-level radiation. However, almost all studies confirm that there is no level at which radiation is safe.[11] The effects of low-level radiation doses include cell death, genetic mutations, cancers, leukemia, birth defects, and reproductive, immune and endocrine system disorders, and acceleration of the aging process.[12]

NUCLEAR WASTE

Nuclear power generation creates radioactive risks at every stage of the nuclear fuel cycle, from the mining and processing of uranium ore to the transport and disposal of highly radioactive spent nuclear fuel. Because spent fuel rods contain such high levels of radiation, it could be argued that the greatest danger from nuclear power generation for generations to come lies in the inadequacy of all spent fuel disposal methods that have been identified.

Spent Fuel

Each year, the average 1,000 MW nuclear power plant produces about 500 pounds of plutonium and about 80,375 pounds of other high-level radioactive waste.[13] A single large nuclear-power plant produces as much radioactive material *in one year* as a 25 megaton atomic explosion.[14]

Radiation from Nuclear Power Plants Threatens Children's Health

The more rapidly dividing cells of the human embryo are more sensitive to the effects of radiation than slowly dividing cells in adults such as brain or bone cells. Radiation exposure to a fertilized egg, embryo or fetus can cause death, birth defects, mental retardation, childhood or early life cancers and a host of other developmental problems.

An epidemiological study published in the spring 2000 issue of the scientific journal *Environmental Epidemiology and Toxicology* suggests that infants of 42 million Americans who live downwind and within 50 miles of a nuclear plant may be at risk.

The study, conducted by Joseph J. Mangano, a research associate at the *Radiation and Public Health Project*, examined infant death rates in counties within 50 miles and in the prevailing wind direction of five reactors: Fort St. Vrain (located near Denver, CO), LaCrosse (near LaCrosse, WI), Millstone/Haddam Neck (near New London CT), Rancho Seco (near Sacramento, CA.) and Trojan (near Portland, OR). It found that in the first two years after a nuclear reactor closed, infant death rates in the downwind counties under 40 miles from the plants fell 15 to 20 percent from the previous two years, compared to an average U.S. decline of just six percent between 1985 and 1996.[15]

Fuel from the core of nuclear power reactors accounts for the majority of high-level radioactive waste produced in the world. This irradiated, "spent fuel" is the most radioactive material on the planet and accounts for 95% of radioactivity generated in the last 50 years from all sources, including nuclear weapons production.[16] Because of the extreme hazards to public health and the environment associated with such a large amount of radioactive materials, experts estimate that spent fuel must be contained for at least 10,000 years.

As long as a nuclear power plant operates, it continues to generate spent fuel. Radioactive byproducts of the nuclear fission process build up in nuclear reactor fuel to the point that they interfere with the efficient release of energy. This necessitates the replacement of approximately one-third of the "spent" nuclear fuel each year. This highly radioactive spent fuel is removed from the reactors and stored in cooling ponds, surrounded by water that helps absorb the heat and radioactivity emitted by the fuel rods.

The United States has never had a plan for safe disposal of spent fuel. When the nation's nuclear power plants were first designed, it was projected that the spent fuel rods would be removed from the cooling ponds and sent to a facility for reprocessing, where plutonium would be extracted for use in nuclear weapons production. However, since President Carter signed a treaty to stop nuclear weapons proliferation in 1977, the United States no longer reprocesses spent fuel.

In the absence of a safe long-term storage solution for nuclear waste, spent fuel often is simply left in reactor cooling ponds that were never designed for the long-term storage of nuclear waste.[17] As the fuel ponds at dozens of the nation's reactors approach full capacity, spent fuel is increasingly being loaded out of the cooling ponds into dry cask storage facilities on-site until the issue of permanent nuclear waste disposal is resolved.

Over a thirty-year period from 1968 through 1998, the nation's commercial nuclear reactors discharged more than 135,000 spent fuel assemblies, containing more than 42,000 metric tons of uranium and 2 billion curies of long-lived radioactivity.[18] As of 1998, more than 97% of this spent fuel remained in storage at commercial reactor sites.[19]

By 2009, DOE projects that the nation's commercial nuclear reactors will have generated more than 61,700 metric tons of spent fuel, most of which will continue to lie in relatively vulnerable spent fuel ponds.[20]

Shortage of temporary storage space and the absence of long-term storage plans for spent nuclear fuel are serious problems for at least 70 nuclear power plants throughout the country. If existing nuclear power plants are allowed to continue operating until the end of their current licenses, the Department of Energy estimates that storage space for an additional 11,000 tons of spent fuel will be needed.[21]

The DOE estimates that the nation's nuclear reactors will discharge 232,000 fuel assemblies through 2030.[22] Each fuel assembly can weigh up to 1500 pounds and store 750 pounds of radioactive uranium.

Spent fuel assemblies are extremely "hot," or radioactive, when first removed from the core of a nuclear power plant. After one year, the average spent fuel assembly from a boiling water reactor like Oyster Creek emits 2,500,000 Curies of radiation.[23] After they are removed from the reactor core, the assemblies are placed in cooling ponds in which water shields the radiation for at least five years. After five years, the average assembly has "cooled" by more than 75%, down to 600,000 Curies. Even after 50 years, however, spent fuel is so highly radioactive a person exposed to it would be killed instantly. It will take tens of thousands of years for spent fuel to cool to levels where the health impact of exposure to it would be negligible.[24]

Federal Regulation of High-Level Nuclear Waste

In 1980, as high-level radioactive waste continued to build up, Congress passed the Low-Level Radioactive Waste Policy Act making disposal of non-federal low-level waste a responsibility of the states and making disposal of commercial reprocessing wastes a federal responsibility.

Two years later, Congress passed the Nuclear Waste Policy Act requiring the Department of Energy to create a permanent geologic repository to begin accepting spent nuclear fuel by 1998. As early as 1957 the National Academy of Sciences had suggested that radioactive waste should be disposed in a stable geologic medium, such as salt. An early effort at disposal in a salt mine in Lyons, Kansas proved problematic and was abandoned in 1971. By 1987, however, amendments to the Nuclear Waste Policy Act limited the search for a federal repository to only one site, Yucca Mountain, Nevada, located 80 miles northwest of Las Vegas at the intersection of three federal lands.

On February 15, 2002, President Bush officially moved to require Yucca Mountain to accept a total of 77,000 tons of highly radioactive waste, largely spent fuel from nuclear power plants. In July 2002, Congress voted to approve the siting of a federal repository for highly radioactive waste at Yucca Mountain, overriding resistance by communities throughout the country as well as local communities and the governor of Nevada.

It is not yet clear whether a court challenge, by the state of Nevada, for example, or further findings by government scientists that the site is unsuitable will stop the Yucca Mountain plan from being implemented. Congress will need to vote at least once more, to budget another $20 billion to drill 100 miles of tunnels under the mountain for hazardous waste storage.[25]

To date, the federal government already has spent more than $6 billion and 25 years studying the feasibility and safety of Yucca Mountain as a permanent repository for high-level nuclear waste. More than $13 billion has been raised from ratepayers' monthly bills and taxes.[26] If the Yucca Mountain project moves forward according to the Bush Administration's plan, it would accept the first spent fuel shipment in 2010 at the earliest, accepting a maximum of 3000 metric tons of nuclear waste each year.

The Problems with a Federal Nuclear Waste Repository: Yucca Mountain

After more than fifteen years and millions of dollars of studies, there is no scientific consensus that Yucca Mountain, which is crisscrossed with geologic faults, would be a safe permanent repository for the nation's nuclear waste.

Studies sponsored by the Department of Energy have shown that Yucca Mountain is not a sound site for permanent storage of nuclear waste. The area is intersected by 33 earthquake faults, and the site lies only 12 miles from the epicenter of a 1992 earthquake that measured 5.6 on the Richter scale.[27] Studies also show that water travels more quickly through the mountain than originally anticipated, which is of concern since the presence of water increases the chance that the storage casks will corrode in a relatively short span of time. A complex computer model developed at the Lawrence Livermore Laboratory suggests that mineral-laden water will be driven from surrounding rocks by the heat from the nuclear wastes and will drip down or condense on the storage casks. This also threatens to contaminate an aquifer that currently provides the sole source of drinking water for a nearby community.

Even if there are no unanticipated exposures, in developing plans for Yucca Mountain, regulators are allowing unacceptable impacts to the public. They are starting with the assumption that the annual exposure to individuals in the area should be limited to 100 millirem. The lifetime cancer risk from this dose is 3×10^{-3}, 3 cancers for every 1000 exposed. This standard of protection does not come close to living up to health-protective limits established by Congress in other industries, in which a 1- in-1 million risk was established as the benchmark.

Furthermore, the Yucca Mountain Site will run out of room before it can take the spent fuel from existing power plants, to say nothing of new ones or additional waste produced by a plant whose license has been extended. As of 2002, 44,000 metric tons of commercial used nuclear fuel and about

Table 1. Spent Fuel Storage at New Jersey's Reactors[32]

Plant Name	Core Size	Spent Fuel Pool Capacity	Assemblies Stored	License Expires	Lose Full Core Offload Capability	Dry Cask Storage
Oyster Creek	560	2645	3025	2009	LOST	YES
Hope Creek	764	4006	1708	2026	2008	NO
Salem I	193	1632	772	2016	2012	NO
Salem II	193	1632	584	2020	2016	NO

12,000 metric tons of defense high-level radioactive waste have already been generated.[28] Given that the nation's nuclear plants generate an additional 2,000 metric tons each year, in eleven years (by 2013) the total waste generated by our nation's nuclear plants will have exceeded the 77,000-ton limit designated by Congress for storage at Yucca Mountain.

Thus, Yucca Mountain, a flawed solution at best, will fail to provide storage for radioactive waste generated after 2013. Considering that more than 20 nuclear power plants are licensed to operate beyond 2025, significant amounts of radioactive waste will be generated over the next twenty years with no disposal option on the horizon. Three years after Yucca Mountain would begin receiving waste in 2010, there would be enough waste sitting at reactors across the country to completely fill the dump. Put another way, if all the nuclear reactors in the United States shut down the day Yucca Mountain opens, their waste would barely fit in the repository.[29]

Spotlight on New Jersey: Even If Yucca Mountain Opens, Waste Will Be Stranded in New Jersey

The Environmental Working Group analyzed how much excess nuclear waste will have been generated at the nation's nuclear power plants when Yucca Mountain reaches its maximum capacity of 77,000 metric tons.

Their analysis found that when Yucca Mountain reaches full capacity, New Jersey would still be left with 1731 metric tons (380,000 pounds) of highly radioactive waste. If Oyster Creek were relicensed to operate for another 20 years, we estimate it would generate an additional 640 metric tons (1.4 million pounds) of stranded highly radioactive nuclear waste.[30]

Spent Fuel in New Jersey

More than 1,688 metric tons of spent nuclear fuel have already been generated by and stored at New Jersey's four nuclear reactors.[31] The radioactivity of this spent fuel far surpasses the radioactivity stored at the core of the reactors.

As described earlier, plans are in place for this spent fuel to be transported to a federal waste repository. Since 1983, consumers of electricity from New Jersey nuclear plants have committed more than $808.5 million into the federal Nuclear Waste Fund to finance this process, which continues to pose a range of risks and uncertainties that may not be resolved in the near future.

In the meanwhile, however, two of the four nuclear plants are already confronting waste storage problems. Oyster Creek outgrew its capacity to store all the spent fuel it has generated in its cooling ponds in November 2002, and Hope Creek is projected to exceed its capacity in 2008. (See Table 1.)

After thirty years of operation, Oyster Creek reached its NRC-recommended capacity for storage of 2600 spent fuel assemblies in 2000.[33] (A typical fuel assembly holds 264 fuel rods.)[34] The plant applied for and was granted permission to add additional storage racks to its spent fuel pool, allowing it to continue operating until it reached a new maximum capacity of 3025 fuel assemblies in November 2002. At that point, having outgrown the storage pools, Oyster Creek implemented an on-site dry cask storage system in order to continue to operate. In "dry cask" storage, fuel assemblies are removed from the cooling ponds (after cooling for at least ten years) and placed in steel or concrete containers, known as dry casks. The assemblies remain highly radioactive.

Oyster Creek finished its first transfer of spent fuel to "dry cask" storage in May 2002, moving four casks containing 61 fuel assemblies into four concrete vaults on the eastern quadrant of the plant's property, approximately 600 feet from Route 9.[35] This dry cask system is projected to hold an additional 1,098 fuel assemblies in 20 casks through 2009[36].

The Risk of Transportation Accidents

The State of Nevada and its residents were not alone in protesting the creation of a federal nuclear waste repository at Yucca Mountain. The Yucca Mountain plan involves moving over 77,000 metric tons of hazardous nuclear waste, involving the transport of an estimated 105,000 truckloads of nuclear waste through 44 states over a span of four decades, even more for longer if plants are relicensed and new plants are built. This would occur at tremendous risk to hundreds of communities through which the waste would pass.

The Nevada Agency for Nuclear Projects recently calculated the risks of transporting nuclear waste using analyses by the Department of Energy and independent consultants. They concluded, "Accidents are inevitable and widespread contamination possible."[37]

A June 2002 study by U.S. PIRG, *Radioactive Roads and Rails: Hauling Nuclear Waste Through Our Neighborhoods*, found that the transportation component of the Yucca Mountain project will pose serious risks to the health and safety of a large cross-section of Americans.

For example, the study documented a DOE proposal to carry thousands of shipments by rail or by barge in transportation casks, each carrying 240 times the long-lived radioactive material that was released at Hiroshima.

According to an analysis of the Department of Energy's Yucca Mountain environmental-impact statement data,[38] a worst-case, high-level, nuclear waste accident in an urban setting could have an economic cost of $37 billion for a truck-transported cask and $270 billion for a rail cask. Using DOE accident rates based on general truck and rail accident records and considering the total miles nuclear waste will be transported, Public Citizen calculated that 210 to 354 accidents would result from the 30 year process of shipping waste to Yucca Mountain.[39] In fact, such accidents are not only likely, but they already have occurred in instances where spent fuel has been transported. The State of Nevada conducted a search of the Radioactive Material Incident Report database operated by Sandia National Laboratories, identifying 49 incidents of accidental surface contamination from accidents involving spent fuel shipments.

Furthermore, even outside of an accident, emissions from passing casks will deliver small doses of radiation to people living within one-half mile of road and rail routes. The DOE acknowledges that commuters stuck in traffic near a highly radioactive waste shipment would be exposed to the equivalent of one chest x-ray per hour.

Spotlight on New Jersey: Shipping New Jersey's Nuclear Waste to Yucca Mountain

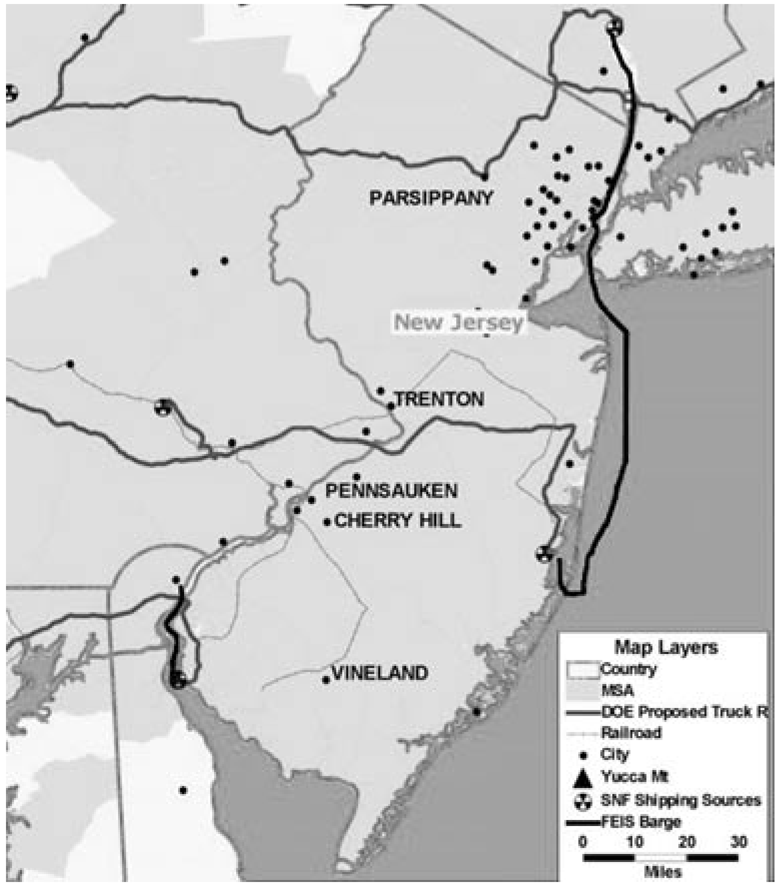
The Department of Energy has proposed several shipment scenarios for New Jersey's nuclear waste, relying on trains, trucks, and barge shipments. As depicted in Figure 2 (see next page), shipping routes would likely pass through or near Trenton, Camden, and other populated areas of New Jersey.

A mapping project launched by the Environmental Working Group found that more than 1 million New Jerseyans live within 1 mile of a proposed nuclear transportation route. The project also found that more than 200 schools and 13 hospitals are located within 1 mile of the routes. From Oyster Creek, the agency proposes either barging waste up the coast to trains in Newark or trucking it up the Garden State Parkway or out Route 195, past Trenton.[40]

If Oyster Creek does not close in 2009 as currently scheduled, it could generate an additional 20 metric tons of highly radioactive waste each year, extending the time frame and frequency of dangerous transport trips.

Under a "mostly truck" transport scenario, the Department of Energy projects 4,544 shipments of nuclear waste will travel through New Jersey en route to Yucca Mountain. Under a "mostly train" shipping scenario, the Department of Energy projects 424 train shipments of deadly, high-level, nuclear waste will travel through New Jersey en route to Yucca Mountain. At least 244 barge shipments of nuclear refuse would be shipped via the Long Island Sound or from New Jersey's Salem and Hope Creek reactors via the Delaware River to the Port of Wilmington Delaware.[41] New York's Indian Point Nuclear Power Plant would likely ship from the Port of Jersey City, via the Hudson River.

Figure 2: New Jersey Highway, Rail and Barge Routes to Yucca Mountain[42]



OTHER IMPACTS OF THE NUCLEAR FUEL CYCLE

Routine Emissions of Radioactivity

The nuclear industry spends millions of dollars telling the public that they are the "emissions-free" energy source. This is completely inaccurate. Nuclear power plants release radioactive air emissions as part of their routine operation.

In the year 2000, Oyster Creek topped the list of boiling water reactors with the most emissions of radioactive iodine. The North American Technical Center prepared a database of radioactive emissions from United States nuclear power plants. This effluent database is the official data provided to the United Nations for their global report on human exposure to radiation from nuclear power plants. An analysis of this data for 2000 (the most recent year available) shows that Oyster Creek had the highest level of radioactive iodine air emissions of the nation's 37 boiling water reactors. (See Table 2). Oyster Creek's routine emissions of airborne particulates were the fourth highest (following only Dresden, Hope Creek, and Nine Mile).[43]

From 1999 through 2001, routine radioactive air emissions from Oyster Creek totaled more than 599 Curies of noble gases, 212 Curies of tritium (radioactive hydrogen), and 0.25 Curies of radioiodines.[44]

Even assuming this rate does not increase as the plant ages, another twenty years of operation would result in direct release of 3,993 Curies of noble gases, 1,400 Curies of Tritium, and 1.6 Curies of radioiodines into Ocean County's air and water. By contrast, a large medical center with as many as 1,000 laboratories in which radioactive materials are used may have a combined inventory of only about two curies worth of radioactive materials.[45]

Without conducting complex and controversial modeling analyses, it is difficult to calculate the exposure of an individual living near the plant or eating food grown in the vicinity from these routine emissions. There are many exposure pathways: people may be exposed to the plant's radioactive emissions through direct inhalation, or by consuming plants and animals that have incorporated the radioactive substances. Two facts are clear however: no exposure to ionizing radiation may be considered harmless, and the exposure levels used in risk analysis calculations by the federal government are likely to be off by a factor of hundreds, if not thousands. So although these emissions may be routine, they pose real health risks that should not be ignored.

Uranium Mining and Milling

Nuclear power generation depends on uranium for fuel. U.S. power plants use more than 40 million pounds of uranium fuel each year.[46] In terms of radiation doses and numbers of people affected, uranium mining is one of the most hazardous steps in the nuclear fuel chain. Mining produces large amounts of waste in the form of low-grade uneconomical uranium-bearing materials that are not managed as radioactive waste.

In the United States, uranium is mined from sandstone deposits in the same regions where coal is found. The Department of Energy estimates that the U.S. has proven uranium reserves of at least 300 million pounds, primarily in New Mexico, Texas and Wyoming.[47]

After uranium ore is mined, uranium is extracted, leaving behind large volumes of uranium mill tailings. These byproducts contain the radioactive element radium, which decays to produce radon, a radioactive gas. The radium in these tailings will not decay entirely for thousands of years.

Many tailings sites all over the world remain unremediated and neglected, polluting ground and surface water with radioactive and non-radioactive toxic substances, such as polychlorinated biphenyls (PCBs), chlorine, ammonia, nitrates, zinc and arsenic.[48] While only one conventional uranium mill is currently operating in the United States, the Department of Energy is still working to remediate contaminated groundwater at thirteen sites where uranium milling formerly occurred.[49]

Table 2. Top Five Boiling Water Reactors Ranked by Total Radioactive Iodine Emissions in 2000

Rank	Nuclear Plant	Total (GBq)	Total (Curies)
1	Oyster Creek 1	1.8537	0.0501
2	Fermi 2	0.8436	0.0228
3	B. Ferry 1	0.65601	0.01773
	B. Ferry 2	0.65601	0.01773
	B. Ferry 3	0.65601	0.01773
4	LaSalle 1	0.4255	0.0115
	LaSalle 2	0.4255	0.0115
5	Brunswick 1	0.26437	0.00715
	Brunswick 2	0.26437	0.00715

In Utah, for example, toxins leaking from the Moab uranium tailings pile have contaminated local groundwater supplies and traveled down the Colorado River, contaminating the source of drinking water for approximately 25 million people (7% of the U.S. population) in Arizona and Southern California. This highly contaminated groundwater is projected to continue leaking into the Colorado River for approximately the next 270 years.[50]

After uranium is mined, the metal must be refined to boost the concentration of the "heavy" isotope, uranium-235, used in nuclear fission. During the enrichment process significant amounts of toxic and radioactive materials may be released into the air, water, and soil, threatening public health. For example, local residents in the vicinity of an enrichment plant that formerly operated in Portsmouth, Ohio have identified excess cancer rates thirty years after the facility ceased operating. Radionucleides and hazardous chemicals were initially released to the environment with no containment. Although the Department of Energy later started monitoring and remediation of the site, considerable damage has been done.[51] In the United States, only one uranium enrichment facility remains in operation, the Paducah Gaseous Diffusion Plant in Paducah, Kentucky.

Spotlight on Oyster Creek: Impacts of the Full Fuel Cycle

By the end of its life, a nuclear reactor such as Oyster Creek will have manufactured lethal radioactive products equivalent to those from several thousand nuclear bombs. [This report relates radioactivity emissions from nuclear plants in general and Oyster Creek in specific to atomic weapons fall-out several times. It might be helpful to point out that the US discontinued above-ground testing of atomic weapons due to concerns about adverse health consequences from fall-out. I don't know if this spot is the best place to make this point, but it should be made.]

The RAND Corporation published a life cycle analysis of the waste volumes produced by a 1000 MW plant operating for one year in *Managing Wastes With and Without Plutonium Separation*.[53] Scaling these estimates down for Oyster Creek, a 650 MW plant, one can estimate the waste produced over the plant's forty-year life cycle. These estimates are presented in Table 3. (Note: This estimate does not include all the wastes produced during the decommissioning process.)

All of the waste products of the nuclear fuel cycle discussed in this section are predictable consequences of the routine operation of nuclear power plants, even when they are operating safely, according to current regulatory standards. The next section considers the additional risks posed by nuclear power plants in the event of an accidental (or intentional) failure, in which the routine operation is interrupted.

Concerned about the environmental impacts of uranium mining, the New Jersey Legislature passed a law in 1980 banning the exploration for, excavation, and processing of uranium in New Jersey. Although there are no uranium mines or enrichment facilities in New Jersey, New Jersey's nuclear power generation contributes to environmental and public health degradation wherever uranium is mined and milled.

"Low-level" Radioactive Waste

In addition to highly radioactive spent fuel and waste produced during uranium mining and milling, nuclear power production generates large amounts of "low-level" radioactive waste, much of which would be categorized as "intermediate-level" waste if such a category existed here, as it does in Europe. Nearly every reactor component that has contact with radioactive fuel or water becomes low-level waste. This includes hardware, pipes, control rods, resins, sludges, filters, evaporator bottoms, poison curtains. Upon decommissioning, the entire nuclear plant, including concrete and steel, will be low-level radioactive waste.

The storage of even low-level radioactive waste poses a threat to water supplies throughout the nation. For example, at the Hanford Nuclear Reservation in Washington, 67 of 177 underground tanks have leaked more than one million gallons of waste, contaminating groundwater and threatening the Columbia River.[52]

In addition to the radioactive waste described above, nuclear power generation results in routine releases of radioactive water and air emissions, which current regulation allows to be released into the environment at "permissible" levels. The Nuclear Regulatory Commission relies on self-reporting and computer modeling from reactor operators rather than independent monitoring to track these radioactive releases and estimate how radioactive pollution is being dispersed. Consequently, factors which may concentrate rather than disperse radioactive emissions and thus expose populations to non-"permissible" levels are unlikely to be discovered until after the harm is done.

THE RISK OF CATASTROPHIC ACCIDENTS AT NUCLEAR POWER PLANTS

"No acts of God can be permitted."

Hannes Alfven,
Nobel laureate physicist

The worst nuclear reactor accident on U.S. soil occurred at the Three Mile Island (TMI) reactor in Harrisburg, Pennsylvania, on March 28, 1979. In this accident, a partial core meltdown necessitated the evacuation of nearly 150,000 people and resulted in the direct release of hundreds of thousands of gallons of radioactive water.

The accident resulted from a combination of human and mechanical error— a plant malfunction combined with operator override of automatic safety systems.

Table 3. Waste Produced by Nuclear Power Generation at Oyster Creek Over 40-Year Lifetime[54]

	Estimated Cubic Meters Produced	
Waste Type	**Over 40 years**	**Over additional 20 years**
Highly Radioactive Spent Fuel	676	338
Intermediate Level Waste	850-1150	430-570
Low Level Waste	11,900-16,200	5,900-8,100
Mining Tailings	1,690,000	845,000

Following the meltdown, it took twelve years and over $970 million to clean up and decontaminate the plant. Much of the litigation that followed is under seal, but public records show that GPU (the plant's owner at the time) and the nuclear industry have paid out at least $50 million to plaintiffs from TMI-related suits brought against them.

A study of cancer rates following the TMI accident was conducted by Dr. Steven Wing, associate professor of epidemiology at the UNC-CH School of Public Health. He and his colleagues found that following the accident, lung cancer and leukemia rates were 2 to 10 times higher downwind of the Three Mile Island (TMI) reactor than upwind.

Congressional investigations in the aftermath of Three Mile Island reported that

". . . an attitude of complacency pervaded both the industry and the NRC, an attitude that the engineered safeguards built into today's plants were more than adequate, that an accident like that at TMI would not occur - in the peculiar jargon of the industry, that such an accident was not a credible event."

But Three Mile Island is not the United States' only major nuclear accident, nor does it represent a worst-case scenario for the potential impact of a major nuclear accident. A 1982 study by the Sandia National Laboratories found that a serious accident at a U.S. nuclear reactor could cause hundreds to thousands of deaths in the near term.[56]

Early fatality estimates ranged from 700 for a small reactor to 100,000 for one of the larger ones. Cancer death estimates ranged from 3,000 to 40,000. Injury estimates ranged from 4,000 to 610,000. For comparison, the atomic bomb dropped on Hiroshima killed 140,000 people and the one dropped on Nagasaki killed 70,000 people.[57]

The Nuclear Fuel Cycle and Global Warming

Proponents of nuclear power argue that since the nuclear fission process emits no carbon dioxide, increasing nuclear power production can help address global warming. As discussed in previous sections of this report, nuclear power generates vast quantities of radioactive waste that may threaten public health for generations to come, and should therefore not be considered an acceptable alternative to fossil fuel combustion simply on the basis of its relatively smaller contribution to global warming.

Furthermore, while electricity generated from nuclear power does not directly emit carbon dioxide (CO_2), an analysis of the nuclear fuel cycle reveals that nuclear power does result in carbon dioxide emissions from mining, fuel enrichment and plant construction. Uranium mining, in fact, is one of the most carbon dioxide-intensive industrial operations.

When the entire nuclear fuel cycle is considered, energy generated from nuclear power releases 4-5 times more CO_2 per unit of energy produced than renewable energy sources like wind and solar.[55] Furthermore, nuclear power generation releases up to 20 times more CO_2 than saving the same amount of power with energy efficiency measures.

An effective strategy to address global warming requires significant advances in energy efficiency and renewable energy production, not increased dependence on nuclear power.

Case Studies: Near Misses in the U.S.

Dozens of accidents have demonstrated that current safeguards and regulations are not enough to guarantee the nation's nuclear power plants will function according to plan in the future. Here are some of the more notable reactor accidents that have occurred in the United States.

The Sodium Graphite Reactor (SGR) Meltdown Threatens Los Angeles

Atomics International, with its industry partners and Atomic Energy Commission support, built a sodium-cooled, graphite-moderated reactor experiment at its test site at Santa Susana, a suburb of Los Angeles. In 1959 the reactor melted its core after powering some light bulbs in a demonstration run. Ten of 43 fuel assemblies were damaged due to lack of heat transfer and radioactive contamination was released, endangering the city of Los Angeles. The public was not notified of the release.[61]

SL-1, Idaho Reactor Accident Kills Three

SL-1, a small "inherently safe" reactor was shut down for routine maintenance on January 3, 1961. A nuclear explosion killed the three-man maintenance crew and contaminated the reactor building. The investigation following the incident revealed that the reactor control rod had been manually withdrawn by about 50 cm, largely increasing the reactivity and causing a power surge in which the reactor reached 20,000 MW in about .01 seconds, causing its fuel to melt. The molten fuel in turn interacted with the water in the vessel, producing an explosive formation of steam.[62]

Fire at Browns Ferry Power Station, Alabama

On March 22, 1975, at the Browns Ferry Power Station boiling water reactor on the Tennessee River, near Decatur, Ala., a worker looking with a candle for air leaks set fire to control cable insulation. Fire spread over control wires for three of the world's largest reactors, two of which were at full power, disabling the reactor cooling systems. Catastrophic meltdown of one reactor was narrowly averted.[63]

Chernobyl: The Catastrophe that Could Never Happen, Did

To date, Chernobyl remains the most well-known and tragic illustration of the potentially catastrophic consequences of an accident at a nuclear reactor. In 1986, an explosion and fire at the Chernobyl nuclear reactor in the Ukraine released over 80 million curies in ten days, generating a plume that deposited radioactive fallout on every country in the Northern Hemisphere. Although it is difficult to calculate the overall costs of Chernobyl, Ukrainian officials have linked the Chernobyl disaster to 4,300 deaths and serious illness in 3.5 million people, destruction of 250,000 to 375,000 acres of agricultural land, and ten to fifteen billion dollars in damages.[58] [59]

The Soviet government estimated that the economic cost of the Chernobyl accident by 1990 had surpassed the collective economic benefits from *every* Soviet nuclear power reactor operated from the initial one in 1954 through 1990.[60]

Errors at Indian Point, New York City

An October 1980 error flooded the cavity of Indian Point No. 2 reactor, 25 miles from New York City, with brackish Hudson River water, closing the reactor until June 1981 and drawing penalties from the Nuclear Regulatory Commission.[64]

On February 2, 2000, a steam tube ruptured, releasing radioactive steam at Indian Point 2. The plant been scheduled for steam generator tube replacement in 1993, yet this replacement never happened, due to increasingly lax NRC requirements.

Davis Besse Nearly Blows Its Top, Toledo

For four years or longer, coolant containing Boric Acid had leaked onto the lid of the Davis-Besse nuclear reactor, eating through more than 6 inches of the heavy steel lid designed to contain the pressure that builds up in the core of the reactor. By the time the dangerous hole was discovered, only a quarter inch of steel liner remained preventing the reactor from literally blowing its top. Subsequent investigations revealed that the corrosion may have been discovered earlier, or prevented, if the Nuclear Regulatory Commission had more aggressively enforced a similar corrosion problem found on a leaky reactor valve at the same plant in 1998. In fact, a plant engineer who had argued for the need to clean and inspect the reactor lid had been first ignored and then fired by management at Davis-Besse, who did not want to spend the time and money that such action would require.[65]

Spotlight on Oyster Creek: Near Miss, 35 Days After Three Mile Island[66]

Just one month after the disaster at Three Mile Island, a potentially catastrophic release of radiation was narrowly averted at Oyster Creek Nuclear Generating Station. This accident is a particularly good example of how quickly problems can arise even in the course of routine maintenance of a nuclear reactor, and how small problems can pile up, overwhelming even systems designed to be redundant to ensure safety. David Lochbaum's description of the accident in *Everything You Know Is Wrong: Nuclear Power's Secrets* is excerpted below in its entirety.

> *A technician testing switches on May 2, 1979, at the Oyster Creek plant in New Jersey caused a false signal of high pressure inside the reactor vessel. This false signal automatically tripped the reactor, which caused the turbine to be shut down seconds later. The turbine trip caused the plant's internal power supplies to transfer from the auxiliary transformers to the startup transformers.*
>
> *However, one of the two startup transformers was unavailable due to maintenance. Two of the three feedwater pumps were powered from the unavailable startup transformer and stopped running when the auxiliary transformers de-energized. The third feedwater pump automatically tripped during the feedwater system transient. Operators couldn't restart this feedwater pump because its auxiliary oil pump was broken.*
>
> *With the loss of all three feedwater pumps, the only water supply to the reactor vessel was provided by the two control rod drive pumps, which didn't provide enough water to the reactor vessel to make up for the all the steam being pumped out. Consequently, the water level dropped until it was a mere twelve inches above the top of the irradiated fuel assemblies in the reactor core. The normal water level is more than ten feet above the core.*
>
> *About 36 minutes after the scram (i.e., the rapid shutdown of a reactor by insertion of its control rods), the operators restarted one of the feedwater pumps, and reactor vessel water level was quickly restored to the normal operating band. A few minutes' delay would've probably caused the reactor core to be uncovered. As at Three Mile Island Unit 2 just 35 days earlier, uncovering the reactor core could've triggered its meltdown.*

Raising Risk: Aging Reactors

In 1985, in response to a question posed by Representative Ed Markey, an NRC commissioner estimated a 45% chance of a severe nuclear accident in the following twenty years.

This risk may be even higher today. Shutting down a reactor for one day to perform maintenance or safety checks can cost the plant's owner $300,000 to purchase power from other sources. Dr. Shirley Ann Jackson, a former director of the Nuclear Regulatory Commission, has testified to Congress her concern that private ownership of nuclear reactors combined with less profitability in the competitive electricity market may lead companies to run plants longer and resist these costly shutdowns, compromising maintenance and safe operation.

Furthermore, the nation's 103 operating reactors may be more vulnerable to breakdown than ever before as they age. Vice President Cheney acknowledged the aging problem on the television show "Hardball" on March 21, 2002: "[T]oday nuclear power produces 20 percent of our electricity, but that's going to go down over time because some of these plants are wearing out."

When the nation's fleet of reactors was built, industry and federal regulators assured the public that the reactors would be shut down and decontaminated when their forty-year operating licenses expired. Now, with the strong support of the Bush administration, the industry is pushing to extend the life of aging reactors for another 20 years, despite mounting evidence that as nuclear plants grow old, they also grow increasingly unsafe.

More than 30 percent of nuclear power plant equipment failures in recent years can at least partly be attributed to age-related degradation.[67] For example, following the discovery of cracks and leaks at the twenty-five year old Davis-Besse nuclear power plant in Toledo, Ohio, a whistleblower leaked a confidential analysis from an influential group within the nuclear industry. According to a journalist for the Cleveland Plain Dealer, this analysis from the Institute of Nuclear Power Operations referred to the corrosion at Davis-Besse, stating that "given plant aging and materials issues…[T]his type of event is likely to recur."[68]

Yet current federal regulations governing nuclear power plant relicensing allow plant operators to ignore the realities of age-related degradation, basing risk calculations on the assumption that all equipment fails at a constant rate. Such an assumption is directly contradicted by hundreds of technical reports that have been issued by the Nuclear Regulatory Commission about the degradation of valves, pipes, motors, cables, concrete, switches, and tanks at nuclear plants caused by aging.

These reports indicate that the failure rate of nuclear power plants follows a standard bathtub curve.[69] In other words, a high rate of failure in the beginning of a plant's operation is followed by a low, relatively constant failure rate and concludes with a wear-out period that exhibits an increasing rate of failure—the period at the end of the reactor's lifetime.

Age-related degradation at older reactors may be widespread, even in reactors that have recently been inspected and given a clean bill of health. Duke Energy Corp.'s Oconee nuclear plant near Greenville, S.C. recently won a license renewal from the NRC for an additional 20 years. Only after the plant passed the extensive relicensing process did maintenance workers at the plant discover that the reactor's cooling system, critical to preventing a nuclear meltdown, had sprung a leak.[70] The ensuing investigation revealed that aging metal on nine nozzles inside the reactor dome had cracked. Two cracks were getting large enough that the nozzles could have broken apart, blocking circulation or causing coolant to gush out and the reactor to overheat—the kind of problem that led to the near-catastrophic Three Mile Island accident in 1979.

VULNERABILITY TO TERRORIST ATTACK

> *"What we have found in Afghanistan confirms that, far from ending there; our war against terrorism is only beginning... We have found diagrams of American nuclear power plants and public water facilities."*
>
> President George W. Bush
> State of the Union, 2002

The vulnerability of the nation's nuclear facilities to a planned terrorist attack can no longer be dismissed as a non-credible threat. Shortly after President Bush's 2002 State of the Union Address, the FBI issued a nationwide alert, citing a known threat against American nuclear power facilities.

Although concerns about the vulnerability of nuclear power plants to terrorist attack are not new, the design of most modern nuclear power plants provides no real defense against an aerial attack. An Argonne National Laboratory study in 1982 estimated the likely damage that a jetliner could inflict on the concrete containment walls protecting nuclear reactors, finding that if merely 1% of the jetliner's fuel ignited after impact, it could create an explosion big enough to breach the plant's containment structure, releasing radioactivity.[76]

However, these concerns have come into greater focus since the September 11th attacks. A study by London-based Large & Associates found that the nuclear industry's current methods of planning for risks based on probability of an accident may "prove

Special Risks of Aging at Oyster Creek

A 1993 Nuclear Regulatory Commission report confirmed that age-related degradation at boiling water reactors could include damage of many vital safety components inside the reactor vessel before the forty-year license expires, such that it could "create conditions that may challenge the integrity of the reactor primary containment systems."

One example of this degradation that has been repeatedly documented at Oyster Creek is widespread cracking in safety-related equipment, a problem that is likely to increase with the plant's age.[71]

Documented History of Cracking at Oyster Creek

The aging of reactor components like the core shroud and spargers (metal pipes used to supply cooling water in the core to avert a meltdown if there is a loss of coolant) poses serious safety risks at boiling water reactors like Oyster Creek, since the plant's ability to contain radiation in the event of an accident is seriously compromised by a structural deficiency in the way the plant was designed.[72]

- 1978 Cracking was first detected in Oyster Creek in the core spray sparger.
- 1980 The plant reported 28 additional cracks in the core spray sparger, including one that extended more than 180 degrees.
- 1982 Oyster Creek reported five additional cracks.
- 1992 Three more indications of cracking were discovered.
- 1994 Oyster Creek reported significant core shroud cracking. This metal cylinder surrounds the radioactive fuel rods, and cracking of the cylinder could damage these rods, leading to a reactor meltdown. Two vertical welds were cracked to a depth of 50-80% of the wall for approximately two-thirds of their length. This finding is serious enough to cause NRC to issue a bulletin to all boiling water reactor owners, and conduct an investigation. NRC concluded that "such cracking will continue as plants age," and consequently, that the probability that all safety-related components of a reactor will develop such cracks is estimated at 100%. NRC finds that such cracking could lead to the inability to insert control rods or cool the core in the event of an accident, but rules that with regular inspection, monitoring, and repair, the risk can be controlled.

To stave off the need to replace the core shroud entirely (which would cost hundreds of millions of dollars and require an 18 month shut down) Oyster Creek opted for a $3 million "quick fix," modifying the core shroud to prevent it from shifting in the event of an accident.

Faulty Containment System at Oyster Creek

According to Paul Gunter of the Nuclear Information and Resource Service, if a combination of human and mechanical errors like those described earlier were to occur again at Oyster Creek, the likelihood that the accident would result in a significant release of radioactivity is particularly high.[73]

Oyster Creek is one of 24 General Electric-designed "Mark I" Reactors, a subset of 35 operational boiling water reactors in the United States. Mark I reactors incorporate a flawed design that may dangerously compromise the operator's ability to "contain" radiation in the event of a nuclear accident.

The purpose of a reactor containment system is to create a barrier against the release of radioactivity. In an effort to control costs, GE's original "Mark I" design included a smaller, less expensive containment system than the large reinforced concrete structures being marketed by competitors. The Mark I containment system has a high likelihood of failure in the event of a nuclear accident, estimated at 90% probability by the NRC's top safety official in 1986.[74]

As early as 1972, the Atomic Energy Commission's top safety official recommended that no further Mark I reactors be built, due to this dangerous shortcoming in the GE design. Three General Electric nuclear engineers publicly resigned, warning Congress of the likelihood of a core meltdown in the event of an accident.

In 1986, an industry workgroup determined it was necessary to alter the Mark I reactors, creating a vent to avert pressure buildup before the containment system failed. This vent system, installed in all Mark I reactors, was built to allow unfiltered release of radioactive high-pressure steam directly to the atmosphere through a 300-foot vent stack in order to prevent a containment breach.[75]

In other words, a faulty containment system that could not withstand a pressure buildup has now been altered so that pressure can be deliberately released by venting radioactive steam directly into the atmosphere, resulting in public exposure.

to be woefully ineffective against intentional and intelligently driven acts of terrorism." The study found that, in the case of an aerial attack, nuclear plants are almost totally ill-prepared for a terrorist attack from the air.

The study also found that the probability of success of a deliberate attack in causing a radioactive release was essentially 100%. "If a terrorist group planned to intentionally crash an aircraft onto a nuclear power station then the probability of the event becomes unity …In other words, there are no practicable measures that might be implemented on site to provide a defense in depth to avert such and event."

Immediately following September 11th, the NRC released a public statement asserting that American nuclear power plants could withstand the crash of a commercial jetliner like those used against the World Trade Center and the Pentagon. However, within days the NRC back-pedaled, stating that the agency had no serious contingency plans for such attack because, as NRC spokesman Victor Dricks stated, "it was never considered credible that suicidal terrorists would hijack a large commercial airline and deliberately crash it into a nuclear power plant."

It is highly unlikely that it would be economic to continue operating the nation's nuclear power plants if they were required to adopt measures to significantly reduce their vulnerability to an aerial attack. The Large and Associates study determined that the enormous investment that would be necessary to physically modify existing nuclear plants to render them less vulnerable is "just not practicably feasible." This fact may help explain the NRC's recently issued policy ruling that a nuclear plant's vulnerability to terrorist attack may not be considered in upcoming relicensing decisions.

This ruling is representative of the NRC's longstanding policy blocking consideration of terrorist acts in licensing proceedings. Because acts of terrorism were unpredictable, the NRC previously argued that the risk of such attacks is not relevant in establishing safety and design requirements.[77] In 1982, the NRC's Atomic Safety and Licensing Board ruled that reactor owners are not required to design against such things as kamikaze dives by large airplanes, arguing that "[r]eactors could not be effectively protected against such attacks without turning them into virtually impregnable fortresses at much higher cost."[78]

Poor Security at Oyster Creek

The Project on Government Oversight (POGO), a nonpartisan, nonprofit government watchdog, interviewed more than 20 security guards at 13 nuclear power plants. Their study, "Voices from Inside the Fences," revealed that security guards at only one in four nuclear power plants described themselves as "confident" their plant could defeat a terrorist attack. The guards, generally subcontracted by the utilities with private guard companies, reported that morale is currently very low and that they are under-manned, under-equipped, under-trained, and underpaid.[79]

NRC insiders also reported to POGO that despite the documented vulnerability of the nation's nuclear power plants to a terrorist attack, plant owners have complained that current scenarios used to test the adequacy of a plant's security are too hard. For example, during a test at Oyster Creek, "one of the mock terrorists took the badge off a 'dead' guard, and used the badge to enter a building unchallenged. The utility was furious, complaining to NRC Commissioners that this was cheating because such a tactic had not been scripted."[80]

Vulnerability of Spent Fuel Pools

> *"Safely securing the spent fuel in crowded pools should be a public safety priority of the highest degree. If the events of September 11 have taught us anything, it is that the war against terrorism will be an unpredictable struggle. The cost of fixing America's nuclear vulnerabilities may be high, but the price of doing too little is incalculable."*
>
> Robert Alvarez, former senior policy adviser in the Energy Department, currently senior scholar at the Institute for Policy Studies

Spotlight on New Jersey: Potassium Iodide Stockpiles

Three months after 9/11, the Nuclear Regulatory Commission (NRC) responded to concerns that the nation's nuclear facilities are vulnerable to such an attack by announcing approval of $1.1 million to fund stockpiles of potassium iodide pills in states with nuclear power plants or near these facilities. As part of a broad terrorism preparedness plan, New Jersey has requested more than 800,000 pills for its residents living near the state's four nuclear power plants.

NRC regulations require distribution of potassium iodide pills as a protective measure against radiation poisoning for the general population, along with evacuation and shelter, in the event of a severe nuclear power plant accident. Potassium iodide administered to children in the immediate aftermath of the Chernobyl meltdown proved effective at blocking the thyroid gland's absorption of radioactive iodine, helping prevent thyroid cancer and other diseases that result from exposure to radioactive iodine in the event of a nuclear catastrophe.

Although current stockpiles are sufficient to provide one or two pills to state residents living within ten miles of a nuclear facility, they will not be sufficient to help residents outside the ten mile emergency planning zone, or unprepared summer tourists who flock to Ocean County towns along the New Jersey coast. Current proposals in the state legislature would extend this coverage, providing potassium iodide tablets upon request to all who live within a 50-mile radius.

But even if there were pills in every medicine cabinet in the state, potassium iodide can only help protect against the initial acute response to a high-level dose of radioactive iodine. It will not mitigate the risk of cancers from other types of radioactive emissions, such as tritium or other noble gases, and will do little to alleviate the large scale impacts on the lives of hundreds of thousands New Jerseyans who live and work in the fallout zone and the devastating economic and long term public health aftershocks that would attend a major nuclear release.

"The NRC staff believes that the likelihood of an intentional aircraft crash into a dry spent fuel storage facility is very small, and even if it were to occur, such an event is unlikely to result in a significant release, if any, of radioactive material beyond the immediate vicinity."[81]

NRC's Official Response on December 10, 2002, to a petition by Edith Gbur, Oyster Creek Nuclear Watch Citizen Activist, which sought to ensure that vulnerability of spent fuel stored at the facility be considered in licensing decisions.

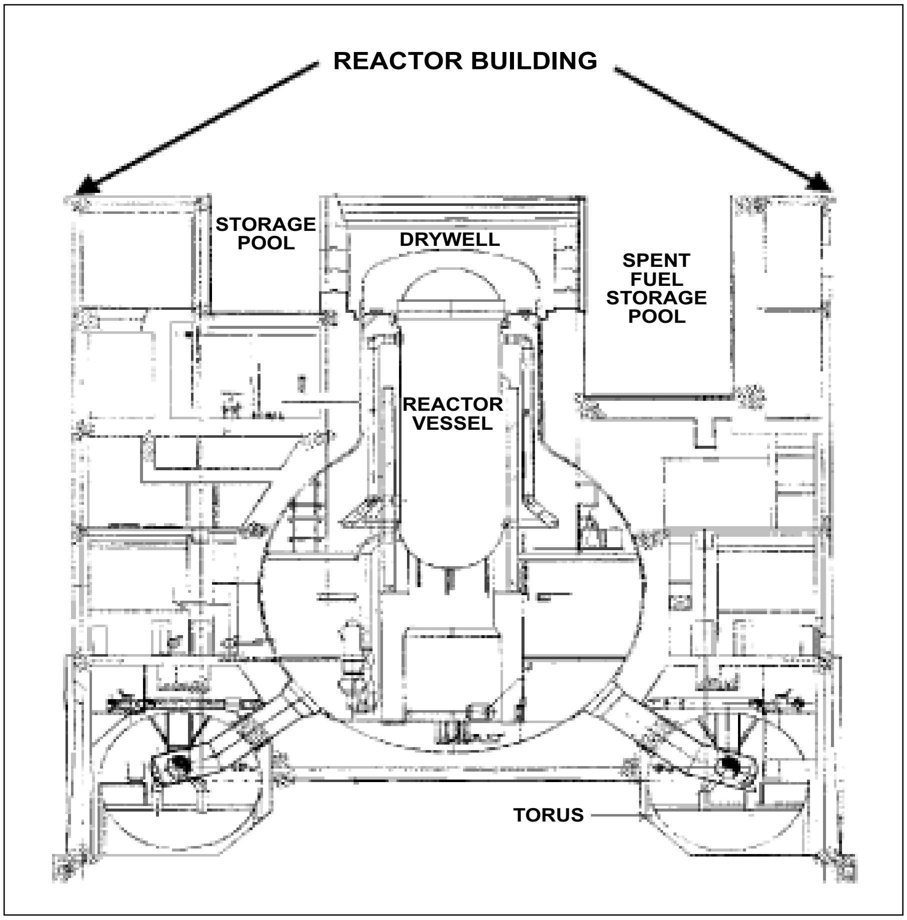
A single spent fuel pond at a reactor that has been operating for 20 years holds more cesium 137 than was deposited by all atmospheric nuclear weapons tests in the Northern Hemisphere combined.[82] Cesium 137 gives off highly penetrating radiation and is absorbed in the food chain as if it were potassium.

Although NRC studies have found that as much as 100 percent of the cesium 137 stored in spent fuel pools would be released into the environment in a fire, the NRC has never tested a power plant guard force's ability to protect spent fuel pools — possibly the prime target of a terrorist attack.

In October of 2000 an NRC study of the effects of accidents at nuclear reactors first recognized the risk posed by spent fuel fires. However, in one hundred pages of analysis, deliberate sabotage by terrorists was never considered.

According to an unclassified study by Brookhaven National Lab, under certain conditions, the spent fuel pool would start draining immediately, resulting in the immediate release of high-levels of radiation in an uncontrolled radioactive fire.[83] This report found that a severe fire in the spent fuel pool could render about 188 square miles uninhabitable, cause as many as 28,000 cancer fatalities, and cost $59 billion in damage.

Figure 3. Oyster Creek's Spent Fuel is Stored on the Roof of the Reactor[87]



Another study found that an accident in a fully loaded fuel storage pool could result in 138,000 deaths at a distance of 500 miles from the reactor, with 31,900 deaths within the 0-50 mile range. The area of condemned land could cover as much as 2,170 square miles at an economic cost of $546 billion excluding health costs.[84]

In the aftermath of September 11, other nations with nuclear facilities have taken action to reduce the vulnerability of their spent fuel. For example, Germany is planning to store dry-casked spent fuel in even more robust containers, and France has installed anti-aircraft missiles around its spent fuel ponds at the La Hague reprocessing facility.

Spotlight on Oyster Creek: Vulnerable Fuel Pools

According to testimony of Danielle Brian, Executive Director of the Project On Government Oversight (POGO) to the Senate Environment and Public Works Committee, boiling water reactors like Oyster Creek may be especially vulnerable in the event of a planned terrorist assault, since their spent fuel pools are above ground.

In effect, a plane crash or an explosive launched from outside the fence line into the side of the pool could lead to an uncontrolled fire exposing the surrounding community to large amounts of radioactivity.

In the case of Oyster Creek, the pool is located on the top floor of a five-story building (see Figure 3). Three of its walls are shared with the exterior walls of the plant. According to an NRC Spent Fuel Accident Risk report, reactors designed like Oyster Creek "do not appear to have any significant structures that might reduce the likelihood of aircraft penetration."[85]

Furthermore, the risks of a loss-of-cooling accident, in which the radioactive substances stored in the spent fuel pool overheat and burn up, are greater at Oyster Creek than at many other facilities, since the pool is not designed to withstand boiling temperatures. As a managing engineer at the plant wrote in 1999:

> *Although many pools are designed to withstand boiling, the OCNGS pool limit is 140°F due to potential structural deflections if large temperature differentials across the pool floor occur. Thus, the large heat removal associated with pool boiling cannot be credited as a method of mitigating a loss-of-cooling accident.*[86]

In other words, if an accident uncovered spent fuel in Oyster Creek's pool, the pool itself would be less likely to be able to withstand the temperature increase that would occur.

Section II: History of Inadequate Federal Oversight of the Nuclear Industry

Under current law, oversight of the nation's nuclear facilities, including Oyster Creek, is almost entirely under the jurisdiction of the federal Nuclear Regulatory Commission (NRC). If Amergen or a future owner of Oyster Creek should decide to apply for a license extension to allow the plant to continue operating, the NRC will have the responsibility of analyzing whether the plant can safely continue to operate, and ultimately, the NRC has the power to grant or deny such a license.

Unfortunately, there is significant reason for concern that the NRC would allow a plant to continue operating despite significant risks to the public. Nuclear industry watchdogs such as the Union of Concerned Scientists, the Nuclear Information Resource Service, and the Project on Government Oversight have documented a consistent pattern of lax enforcement and oversight at the Nuclear Regulatory Commission. As a result of this inadequate oversight, dangerous nuclear power plants have been allowed to continue operating despite known violations of regulatory standards. In the case of Davis-Besse, for example, NRC's own risk guidelines should have prompted the agency to require the plant to shutdown long before the severe corrosion of the lid was discovered, but NRC caved in to pressure from the plant owners who did not want to compromise profits by shutting down the plant to perform the necessary maintenance.[88]

With one-third of the nation's 103 nuclear power plants expected to apply to the Nuclear Regulatory Commission for license renewals over the next three years, it is critical that NRC be reformed to be a more effective regulator of the nuclear industry, leaving behind its roots as the industry's promoter at the dawn of the Atomic Era.[89]

The Beginnings of Nuclear Power Regulation

In 1942, the U. S. became the first nation on earth to produce a self-sustaining nuclear reaction at the Fermi reactor in Chicago.[90] Although President Eisenhower explicitly contrasted the development of nuclear power plants (most famously in his "Atoms for Peace," address to the nation) with the race to build the first atomic weapons that immediately preceded them, nuclear power generation in the United States originated in the development of nuclear weapons during the Cold War.

The Atomic Energy Commission was formed in January 1, 1947 with the twin missions of promoting and regulating the burgeoning nuclear power sector.[91] It took nearly thirty years before Congress passed the Energy Reorganization Act of 1974 in an attempt to avoid the conflict inherent in having the same agency both regulating and promoting nuclear power. As a result of this reorganization, the Atomic Energy Commission was broken into the Nuclear Regulatory Commission and the Energy Resource and Development Administration, later to become the Department of Energy (DOE).

Nuclear watchdog organizations argue that this history in which the Atomic Energy Commission started out as an industry-booster set a precedent by which the NRC has become a "captured agency," putting the profits of the industry it was established to regulate ahead of the health and safety of the public.

Caught Between Private Profit and Public Safety

In January 2003, national newspapers reported on a poll of nearly 1500 NRC employees, conducted by International Survey Research. The poll found that nearly half of the agency's employees did not feel it "safe to speak up in the NRC," and one-third question the agency's commitment to safety. [92]

The poll also revealed that although almost 90 percent of the agency's executive-level employees believed that the NRC had a positive commitment to safety, less than two-thirds of those in the mid-level ranks answered similarly.

NRC's Flawed Decisionmaking at Davis Besse[94]

After determining that numerous safety regulation violations resulted in hazardous operating conditions at Davis-Besse, NRC staff prepared an order requiring the reactor to be shut down by December 31, 2001. The principal focus of the shutdown was to permit inspection of the reactor's control rod drive mechanism nozzles for cracks—cracks that had already been found at every other nuclear plant like Davis-Besse in the United States.

The plant's owner, FirstEnergy, resisted the order, arguing that it could safely operate until its scheduled refueling outage at the end of March 2002. In violation of its own safety policies, NRC caved in, shelving the order and allowing Davis-Besse to continue to operate until a rescheduled outage date six weeks later, February 16, 2002.

When FirstEnergy finally conducted the overdue inspections of the Davis-Besse reactor vessel head, the findings validated the overruled safety concerns of the NRC staff and its senior managers.

As Paul Gunter and David Lochbaum reported in their analysis of the Davis-Besse case,

> "Not only did the company find cracked CRDM nozzles and reactor coolant leakage that NRC staff had forecasted as safety regulation violations, but FirstEnergy also discovered that boric acid ate an unprecedented cavity through 6 inches of carbon steel of the reactor vessel head. The only thing preventing a major accident was a 3/16-inch stainless steel inner liner that bulged but luckily held against the 2,000-plus pounds per square inch pressure inside the reactor vessel."

A "Lessons Learned" Committee reported to Congress in January 2003 that it had identified the following problems with the safety management at Davis Besse:

- The cracked nozzle responsible for the corrosion had leaked for six to eight years before it was detected.
- More than thirty years of foreign and domestic operating experience involving boric acid corrosion events had demonstrated that corrosion rates were consistently underpredicted, but this experience was ignored by NRC staff in their assessments of Davis-Besse safety performance.
- Davis-Besse's owners and operators did not assure that plant safety issues would receive appropriate attention as evidenced by a consistent pattern of minimizing production impacts by proposing long-term, system-based repairs.
- The owner and operators of Davis-Besse had a consistent history of weak self-assessments, multiple examples of procedural noncompliance, lack of management involvement in safety significant work activities, a lack of engineering rigor in their approach to problem resolution, and strained engineering resources.
- As early as 2000 staff engineers had vigorous discussions with senior management to convince them that additional head cleaning activities needed to be conducted before starting the facility up from a refueling outage. Despite their concerns, the plant was restarted before such maintenance measures could take place.

Critics have argued that this lack of a safety culture results from a tendency to value protecting industry profits over public safety, pointing out, for example, that the NRC consistently proposes radiation protection standards that are well below those proposed by the Environmental Protection Agency. In a 1993 NRC Inspector General report, NRC inspectors stated they were dissuaded from finding violations at nuclear power plants, personally receiving penalties if they found violations.[93]

However, the recent near-miss at the Davis Besse reactor in Toledo Ohio, described in the sidebar, perhaps best illustrates the conflicts inherent in the agency. In this case, NRC staff who had recognized the need for prompt inspection at a potentially hazardous facility argued for a shutdown of the plant but were overridden by senior management who themselves yielded to pressure from the plant's owners, First Energy.

Problems with NRC Oversight

> *"The question now facing the NRC is what deregulation will mean for how we go about meeting these safety objectives. For example, what level of assurance does the NRC have that a particular utility will spend the money required for adequate maintenance and for necessary safety upgrades? What changes do we have to make in our inspection program and other evaluation processes to ensure that we stay ahead of any potential degradation in safety at a plant, so that we can detect adverse trends and correct them."*
>
> Dr. Shirley Ann Jackson,
> Former NRC Chairman

The Davis-Besse case study illustrates one problem with current regulation: NRC staff identified a safety hazard, sought enforcement action to protect the public, but caved under pressure from the plant's owners.

A two-year investigation conducted by the Project of Government Oversight concluding in 1996 found that the NRC management allowed the owners of nuclear plants to decide whether to follow the NRC's requested actions or propose their own alternatives, which were consistently accepted by the NRC. In one case, the NRC management accepted all 25,000 opinions made for new technical specifications by the nuclear industry, despite NRC staff objections.[95] The same investigation found that from 1984 to 1996, more than half of the high priority safety problems identified by the NRC were dismissed without requiring any safety improvements. Often such problems were resolved only on paper, waiting more than a decade before actually, if ever, being fixed.[96]

Another problem with current regulation may be even more insidious. Enforcement and safety inspections are often based upon risk analysis calculations performed under overly optimistic NRC regulations depending on assumptions that contradict actual operating experience.

In "Nuclear Plant Risk Studies: Failing the Grade," David Lochbaum of the Union of Concerned Scientists highlighted the following problems with NRC's Risk Assessment Procedures:[97]

- The risk assessments assume nuclear plants always conform with safety requirements, yet each year more than a thousand violations are reported.
- Plants are assumed to have no design problems even though hundreds are reported every year.
- Aging is assumed to result in no damage, despite evidence that nearly 30% of recent equipment failures at nuclear facilities can be attributed to age-related degradation.
- The risk assessments assume that plant workers are far less likely to make mistakes than actual operating experience demonstrates.
- The risk assessments consider only the accident threat from damage to the reactor core despite the fact that irradiated fuel in the spent fuel pools represents a serious health hazard.
- No minimum standards exist to ensure plant owners are calculating accident probability properly.
- Reactor pressure vessels are assumed to be fail-proof. However, cracks in the reactor vessel caused by constant neutron bombardment have been widely documented, and could lead to a meltdown. When calculations performed by plant owners began demonstrating the pressure vessels were out of compliance with existing standards, the NRC changed the safety

margins and allowed the utilities to recalculate their compliance.

- The failure of as few as ten steam generator tubes can lead to a reactor meltdown, yet the NRC has inadequate steam generator tube standards. For example, the Indian Point 2 nuclear power plant is located 24 miles north of New York City, along the Hudson River. It had been scheduled for steam generator tube replacement in 1993, yet this never happened thanks to increasingly lax NRC requirements. On February 2, 2000, a tube ruptured, releasing radioactive steam.

- The potential vulnerability of reactors and spent fuel pools in the event of a deliberate terrorist attack is almost completely ignored.

Given these weaknesses in current oversight and evaluation of our nation's nuclear facilities, there is reason to believe that a plant could win a license extension despite structural flaws that seriously compromise the plant's ability to operate safely.

INADEQUATE OVERSIGHT AT OYSTER CREEK

One consequence of NRC's inadequate focus on protecting public health is that frequently the risks of safety violations at the nation's nuclear power plants, including Oyster Creek, are downplayed. For example, Oyster Creek inspections in 2000 accompanying the sale of the plant to Amergen from GPU identified four major equipment maintenance or operation failures. However, these were all labeled "non-cited violations" that did not result in any enforcement action.

In fact, as Public Citizen documented in a report called *Amnesty Irrational*, the NRC created an amnesty program from October 1996 through March 30, 2001, in which utilities who had failed to comply with their design basis specifications, in clear violation of NRC regulations, were explicitly absolved of responsibility for any violations they reported.

Over three years of this amnesty period, Oyster Creek ranked as one of the top ten reactors most frequently cited by (but not enforced by) the NRC for operating "Outside Design Basis." The plant operated outside the safety and operational parameters established in its license more than 16 times over a three-year period. The reactor operators ignored key safety rules governing emergency core cooling systems and the cables controlling the nuclear reactor's core. Yet these violations resulted in no enforcement action by the NRC.[98]

Safety rules exist to minimize the risk of a potentially catastrophic accident. However plant owners seeking to increase their profit margins have a financial incentive to cut corners and staffing, compromising safety objectives. Without the risk of facing penalties or enforcement actions by the NRC, there is little disincentive to adopt such safety-compromising measures.

INADEQUATE EMERGENCY PLANNING IN OYSTER CREEK'S 10-MILE EVACUATION ZONE

Oyster Creek Nuclear Generating Station is located nine miles south of Toms River, just two miles inland from the Jersey Shore, a popular summer vacation area for the residents of New Jersey, New York, Pennsylvania and Delaware. Although Oyster Creek's emergency management plan recognizes that there is a significant "seasonal population fluctuation," it does not include measures that adequately account for the timely evacuation of the large number of people who are likely to be vacationing at the shore.

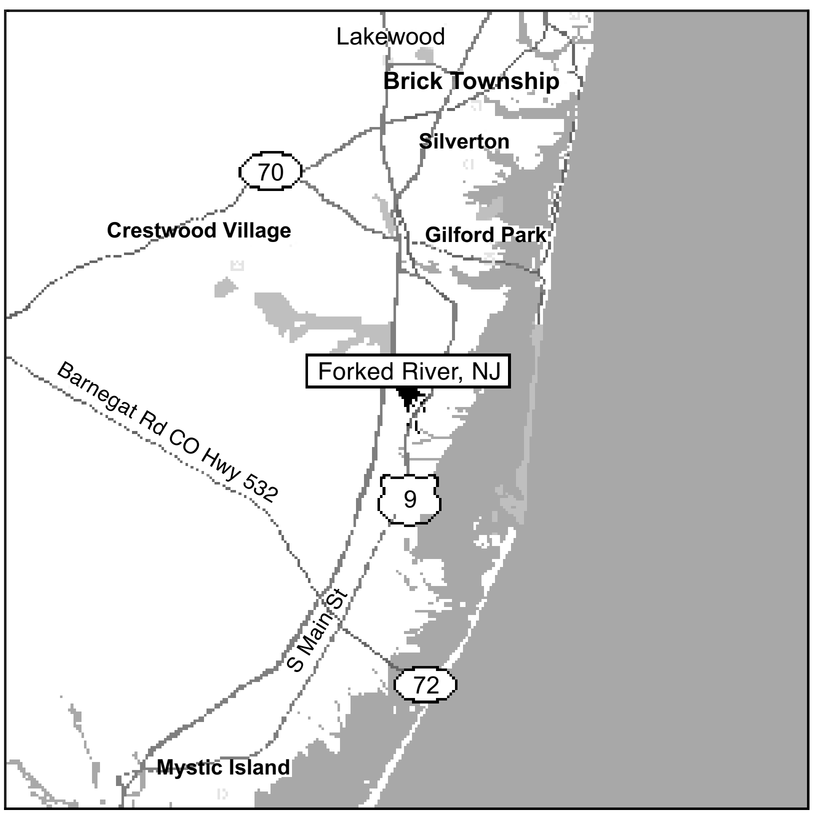
In fact, serious congestion on the barrier islands located within ten miles of Oyster Creek and limited means of traveling from these islands to the mainland make prompt evacuation of these areas nearly impossible. (See Figure 5) One of these islands, Long Beach Island, has only one road on which people can exit the island, the Route 72 Manahawkin Bay Bridge.

Oyster Creek's Emergency Evacuation Plan depends on automobiles as "the principle means of evacuation" despite the fact that there is extensive congestion throughout the ten-mile evacuation radius of the plant, including:

- Route 72 east of the Garden State Parkway
- Route 9 and its feeder roads in Barnegat Township and Stafford Township
- Intersection of Route 72 and Route 9
- Route 554 and its intersection with Route 72
- Long Beach Ave/Central Ave and their intersection with Route 72
- The intersection of Route 9 and Lacey Road, and feeder roads onto both
- The entrance ramp to the Garden State Parkway at Lacey Road and at Route 72
- Route 9 North of the plan until the intersection of Central Parkway/Butler Boulevard
- Intersection of Western Boulevard with County Route 618
- Intersection of Route 9 and Bay Avenue (Route 554)

Based on 1990 population and traffic data, the plan estimated that evacuation time for the 10-mile radius of Oyster Creek in the summer under normal weather conditions would be 7 hours 5 min-

Figure 4. Popular Shore Destinations Near Oyster Creek Have Limited Evacuation Routes



utes. According to the plan, simply evacuating the 2-mile radius of the plant on a summer day would take 3 hours, 5 minutes.

The actual time it would take in 2003 is likely to be significantly higher, since congestion in Ocean County continues to worsen, as the area experiences rapid population growth. In fact, Ocean County's population skyrocketed 18% from 1990 to 2000, more than twice New Jersey's statewide average.[99]

The plan to evacuate people in the ten-mile radius has met federal guidelines. However, this timeline is not quick enough to keep people out of the path of radiation. Depending on the windspeed, it can take as little as 30 minutes to 2 hours for a radiation release to travel 5 miles, and 1 to 4 hours for it to spread 10 miles.[100] The Virginia Radiological Emergency Response Plan estimates that a radioactive plume could travel 10 miles in 1 hour.

Furthermore, there is no plan for evacuation or orderly movement of people beyond the ten-mile radius, despite the high likelihood that they too would be seriously threatened. In fact, the American Association of Clinical Endocrinologists and the American Thyroid Association have recommended that potassium iodide should be distributed to households within 50 miles of a plant, to protect people from absorbing radioactive iodine released during a nuclear emergency. The Association has argued that iodide pill distribution should be just one part of an emergency plan that includes evacuation, sheltering, and avoiding contaminated food, milk, and water in the fifty-mile radius, a plan that simply has not been developed because it is not required by NRC guidelines.

In addition, current strategies to distribute potassium iodide pills to those who live and work near the Oyster Creek plant will have no impact whatsoever in protecting millions of people who flock to the shore for summer day trips.

Section III: New Jersey Does Not Need Oyster Creek

Nuclear power is unsafe, insecure, and generates highly radioactive waste for which there is no effective disposal strategy. Although nuclear power generation is currently a major source of the state's electricity, New Jersey's energy future need not rely on this dangerous power source. Furthermore, the capacity of Oyster Creek Nuclear Power Plant to generate electricity comprises less than 1% of all generating capacity in the electric grid from which New Jersey residents, businesses, and industries get their power.

BACKGROUND: NEW JERSEY'S ELECTRICITY MIX

Nuclear power plants are currently the largest source of electricity generation in the state of New Jersey, responsible for nearly fifty percent of all the megawatt-hours generated in the state over the course of the year. Thus, electricity production in New Jersey is more heavily dependent on nuclear power than the national average, in which nuclear accounts for approximately 20 percent of electricity production.[102] In fact, nuclear plays such a large role in electricity production in only four other states: Vermont, New Hampshire, South Carolina, and Illinois. (See Table 4)

Table 4. Top Five States with Highest Dependence on Nuclear Power for In-State Electricity Generation[103]

Rank	State	Percentage
1	Vermont	67%
2	South Carolina	55%
3	New Hampshire	53%
4	Illinois	50%
5	New Jersey	49%

New Jersey's four nuclear power plants have a combined generating capacity exceeding 3500 MW (See Table 5, next page). Although electricity generated by Oyster Creek Nuclear Power plant only meets a small percentage of New Jersey's total electricity demand (0.8% of the PJM Grid's generating capacity), Oyster Creek is the tenth largest producer of electricity in the state.

Renewable sources currently generate only two percent of in-state megawatt-hours. The remainder, nearly 48%, is generated through the combustion of fossil fuels, including coal, petroleum, and natural gas. (See Figure 5, next page)

In-State Generation at Peak Demand

Nuclear power is a baseload generator in New Jersey. Since it cannot be easily turned off or on, it runs nearly all the time. At peak demand, other generators, such as New Jersey's natural gas turbines, are turned on. Thus, nuclear power represents a smaller proportion of New Jersey's total summer peak generation than its proportion of electricity generated annually. Renewables represent

Note on Units

Megawatts (MW) are the standard measure of the generating capacity of a power plant. Utilities also measure their ability to supply demand on the grid at any one time in terms of MW. Each megawatt of capacity provides enough energy for the annual use of approximately 750 single-family homes.[101]

Power plant output and electricity consumption are measured in terms of megawatt-hours (MWh). A 50 MW power plant operating at full capacity for one hour produces 50 MWh of electricity. This unit indicates the total amount of electricity generated during a period of time. To measure how much such a plant could produce in one year at full capacity, you multiply the capacity by the number of hours in a year (50 MW x 8,760 hrs/yr = 438,000 MWh/yr).

1,000 KWh equals one MWh, and 1000 MWh equals one gigawatt-hour (GWh).

Table 5. New Jersey's Nuclear Power Plants

Nuclear Power Plant	Location	Owner	Generating Capacity in 2001	Type of Reactor	Start of Operation
Oyster Creek	Lacey Township, Ocean County	Amergen	650 MW	Boiling Water	DEC 1969
Salem I	Lower Alloways Creek, Salem County	PSE&G	1,090 MW	Pressurized Water	JUN 1977
Salem II	Lower Alloways Creek, Salem County	PSE&G	1,115 MW	Pressurized Water	OCT 1981
Hope Creek	Lower Alloways Creek, Salem County	PSE&G	1,067 MW	Boiling Water	FEB 1987

less than two percent of the fuel mix at peak demand (See Figure 6).

Figure 5. New Jersey Fuel Mix (Megawatt-Hours)[104]

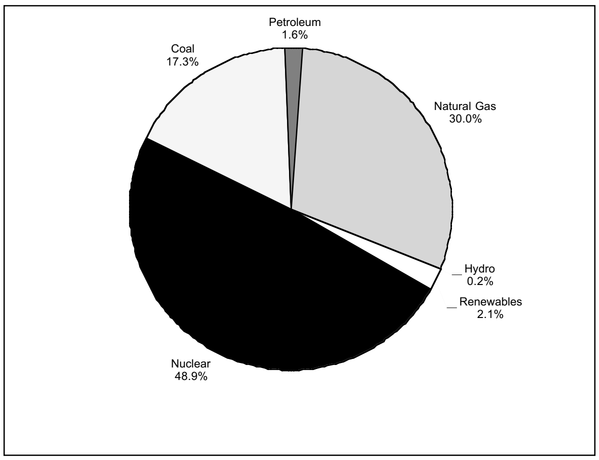
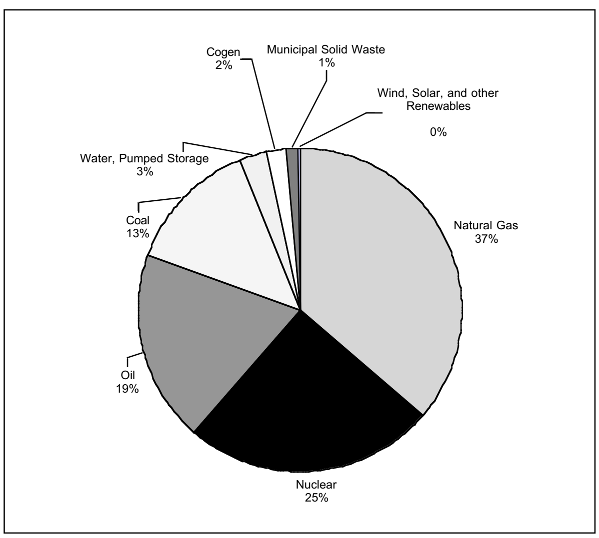


Figure 6. New Jersey's Electricity Generation Mix at Summer Peak (MW)[105]



THE ELECTRICITY THAT ACTUALLY POWERS NEW JERSEY: THE PJM GRID

While nuclear power plants are major in-state electricity generators, New Jersey is not heavily dependent on power generated by any one of the state's four nuclear power plants.

The power consumed in New Jersey is not limited to electricity generated within the state. New Jersey relies on electricity drawn from the PJM electric grid, a network that pools power generated in Pennsylvania, New Jersey, and Maryland. Generators connected to the PJM grid have a combined capacity of 70,000 MW. New Jersey's nuclear facilities contribute less than 5% of this capacity.

Like all electric grids, PJM consists of high-voltage transmission systems that may transport electricity from generation sources hundreds of miles away, and lower-voltage distribution systems, which draw electricity from the transmission lines and distribute it to individual customers.

One consequence of the grid is that New Jerseyans are not specifically dependent on electricity generated within the state. This networked system, in which each distribution system draws power from hundreds of generators throughout Pennsylvania, New Jersey, and Maryland, helps to ensure a high reliability for power delivery.

Another consequence of the grid is that if any one power plant shuts down, the lost power will only constitute a small fraction of the power being delivered by the grid. Oyster Creek's electricity generation, for example, represents less than 1% of the PJM installed capacity in 2002.[106] The current reserve margin, targeted at 20% of the region's capacity, can easily handle the temporary shutdown of a facility the size of Oyster Creek, and indeed, does so whenever a nuclear power plant is shut down for routine maintenance and servicing. Thus, from the perspective of reliability, Oyster Creek contributes a very small proportion of the region's total electricity.

Over the next two years, PJM projects generating capacity to exceed the 20% reserve margin by nearly 13,000 MW, creating the possibility for the PJM grid to export power to neighboring grids.[107] Currently, problems with meeting demand are anticipated to come from limited transmission lines, not limited generating capacity. For this reason, several multimillion-dollar transmission upgrade projects are in development. In the short and midterm, however, the region may rely on other forms of electricity generation to replace Oyster Creek's power production.

REPLACING OYSTER CREEK'S ELECTRICITY GENERATING CAPACITY

New Electricity Generation Already In Development

In the short term, New Jersey can easily replace the 650 MW generated by Oyster Creek with natural gas generation already in development. In fact, more than 3,000 MW of new natural gas generation is scheduled to come online in New Jersey over the next few years.[108]

Although natural gas generators are cleaner than coal-fired power plants and do not pose the same potentially catastrophic risks as nuclear power, natural gas alone should not be relied upon to meet growing electricity demand over the next decade and beyond.

First, combustion of natural gas, while relatively cleaner than other fossil fuels, still results in significant emissions of greenhouse gases such as carbon monoxide and methane and health-threatening toxic volatile organic compounds, emissions avoided by efficiency and renewables.

Moreover, with 90% of new projected generation in the state projected to come from natural gas, there is legitimate reason to be concerned about potential price spikes, particularly when electricity price caps currently in place are removed, leaving ratepayers vulnerable to dramatic fluctuations in natural gas prices.

Increasing electricity generation from truly renewable energy sources such as wind and solar power and reducing demand with energy efficiency programs offer distinct advantages to New Jersey.

Developing the region's renewable resources can help insulate New Jersey consumers from secondary price spikes due to unpredictable fluctuations in natural gas prices. Furthermore, natural gas prices overall will continue to rise, while renewable energy prices will continue to fall. Energy efficiency measures also help reduce peak demand, protecting consumers from high electricity rates.

RENEWABLES AND EFFICIENCY: THE KEY TO MEETING FUTURE ELECTRICITY NEEDS

Since New Jersey derives its electricity from the PJM grid, the state need not meet future demand solely with electricity generated in the state. However, air quality and safety considerations require that this demand be met with clean, renewable sources or energy efficiency measures, not additional combustion of coal or oil, or operation of aging nuclear reactors.

PJM currently projects that summer peak demand in the region will increase by approximately 1.7% each year through 2009. According to PJM's predictions, summer peak demand in New Jersey of 17,806 MW in 2003 is projected to increase to over 20,200 MW by 2009, an increase of nearly 2,400 MW. In the PJM region, summer peak demand is expected to increase by a total of 5,528 MW during the same period.

Fortunately, power generation potential from renewable energy resources in the region combined with efficiency savings can easily surpass these projections in demand growth. Aggressively developing just one resource, wind power, could meet both meet future demand in the PJM grid and replace Oyster Creek. Combining wind with other renewable resources like solar photovoltaics and clean biomass would further benefit the region, and would easily meet new demand if the right policies and programs are developed. For example, New Jersey's use of solar panels has already increased tenfold in the past four years, thanks to the rebates available through New Jersey's Clean Energy Program. If solar panels were incorporated in ten percent of new residential development, more than 20MW of solar power could easily come online each year in New Jersey. (Please see Appendix I for more information about the region's renewable energy resources.)

Improving energy efficiency would further reduce the need for Oyster Creek and other dangerous energy sources. Energy efficiency improvements offer the added benefits of reducing the strain on the electricity grid, reducing pollution from other electricity sources, and saving consumers money.

Historically, the widespread adoption of energy efficiency measures in the face of the 1973 Arab oil embargo contributed to the cancellation of more than 200 power plants nationwide, about half fossil fuel, half nuclear, as demand for electricity dropped.[109]

New Jersey has already made significant strides in improving energy efficiency, but there is room for progress.[110] California's experience, in the face of its energy crisis last year, demonstrated that a concerted effort resulted in a reduction of electricity demand in the state by 6 percent from the same seven-month time period a year earlier, and a peak reduction of 11 percent over the previous year, with continued growth in the state economy. These benefits accrued despite the fact that California already had some of the nation's strongest energy efficiency programs in place.

A study conducted by the American Council for an Energy Efficient Economy demonstrated that New York, Pennsylvania, and New Jersey could cut its electricity consumption by 33% between 1997-2010.[111] New Jersey already has significant resources to promote the development of energy efficiency programs through the New Jersey Clean Energy Program, administrated by the Board of Public Utilities. Close to $100 million dollars each year goes to efficiency programs that teach builders how to construct better buildings and give rebates to consumers buying efficient appliances. Other tools for New Jersey include adopting stronger efficiency standards for common household appliances and updating energy efficiency building codes. Energy efficiency standards for ten common appliances, such as ceiling fans, traffic lights, and clothes washers, are currently under consideration by state decisionmakers, and would shave roughly 300 MW of peak demand by 2010. Increased building codes would reduce peak demand by another 160 MW. (See Appendix.)

In light of the ACEEE study and the potential efficiency gains possible simply by adopting the two programs described above, it is reasonable to conclude that New Jersey could cut its electricity demand by 15% by 2010 (a seven-year period). In so doing, the state would be able to forego the generation of 10,200 GWh of electricity annually by 2010, an energy savings by 2009 equal to that created by a plant with a 1,000 MW capacity plant operating at full capacity 100% of the time.[112]

Policy Conclusions

The continued operation of Oyster Creek beyond its planned lifetime would unnecessarily threaten public health and safety in New Jersey.

New Jersey can shut down Oyster Creek Nuclear Generating Station while continuing to meet its electricity demand by adopting policies to promote the development of the region's clean, renewable resources and reducing overall demand through energy efficiency strategies.

The benefits of such a transition would include decreased potential exposure to hazardous radioactive materials, decreased vulnerability to terrorist attack, and a more reliable energy system. To achieve these goals, New Jersey should:

SUPPORT RETIREMENT OF OYSTER CREEK

Ensure Oyster Creek is Retired in 2009

New Jersey should petition the NRC to deny any license extension that would allow Oyster Creek to continue to operate beyond 2009, when its current license expires.

Intervene in Sale and License Transfer of Oyster Creek

New Jersey should petition to stop the license transfer of Oyster Creek from Amergen unless the transfer guarantees the closure of Oyster Creek in 2009 by expressly stipulating that the buyer shall not apply for a license extension. Furthermore, a license transfer for Oyster Creek should be denied unless and until the Nuclear Regulatory Commission conducts a review of the public safety and health implications of the proposed owner and its parent corporations' nuclear holdings. Furthermore, New Jersey's Homeland Security Task Force should ensure that such a review includes consideration of the nuclear plant's vulnerability to an intentional terrorist attack and other related security issues.

Ensure Current Safeguards Are Adequate During Oyster Creek's Continued Operation Through 2009

New Jersey should carefully reexamine the Emergency Evacuation Plan for Oyster Creek to ensure it adequately accounts for high levels of summer traffic along Route 9 and the Jersey Shore, and probable impacts beyond the federally required ten-mile planning radius.

Advocate for Stronger Federal Regulation of Nuclear Power Plants And Greater Local Control

New Jersey's congressional delegation should work with their colleagues to strengthen federal regulatory oversight of nuclear power plants. New Jersey's state and municipal leaders should work with the Council of Governors to build support for greater state and local control in decision-making related to nuclear power production.

SHIFT AWAY FROM NUCLEAR POWER BY PROMOTING CLEAN, RENEWABLE ENERGY

Strengthen the Renewable Portfolio Standard

New Jersey should increase the renewable portfolio standard to 20% by 2020, and implement enforcement measures to ensure New Jersey reaches this achievable goal. In doing so, New Jersey will create a stable marketplace and demand for clean energy development.

Maintain State Commitment to Purchasing Clean Energy

The state of New Jersey, its counties, and cities should show leadership and spur the marketplace by buying or installing clean energy for government buildings. If the state combines the purchase of renewable energy with energy efficiency measures, the state can actually save taxpayers money.

Undeveloped Potential: New Jersey's Renewable Portfolio Standard

New Jersey's Renewable Portfolio Standard can help ensure the development of more clean power for the regional electricity grid. This standard, established by the legislature during the restructuring of New Jersey's electric utilities in 1999, will require that by 2009, 2.5% of electricity sold in the state to come from wind, solar, fuel cells, geothermal, wave/tidal power, and methane gas from landfills or biomass.

Specifically, the RPS includes a progressively increasing renewable sales requirement, beginning with 0.5% of all New Jersey electricity sales in 2001, rising to 1% by 2006 and 4% by 2012. The requirements can be met through a credits trading program.

Table 8. RPS Required Renewable Energy Sales in New Jersey, Based on Projection of Total Electricity Sales in State

Year	Renewable Standard	Total New Jersey Sales (MWh)	Renewable Sales (MWh)
2000		62,818,825	
2001	0.50%	61,094,049	305,470
2002	0.50%	66,211,057	331,055
2003	0.75%	67,922,806	509,421
2004	0.75%	68,712,242	515,342
2005	0.75%	70,082,683	525,620
2006	1.00%	71,429,676	714,297
2007	1.50%	73,162,267	1,097,434
2008	2.00%	74,644,740	1,492,895
2009	2.50%	76,069,895	1,901,747
2010	3.00%	77,315,277	2,319,458
2011	3.50%	78,649,242	2,752,723
2012	4.00%	79,730,483	3,189,219

Given current projections for total electricity sales in 2009, the RPS translates to a requirement that 1,901,700 MWhrs of energy sold in New Jersey in that year come from renewable sources, equivalent to 650 MW of wind power generating capacity.[113] (See Table 8.)

Unless the RPS standard is raised, however, it is unlikely to lead to new renewable development. Already, more than 6 million MWh of renewables are generated each year in New Jersey, Pennsylvania and Maryland.[114]

Adopt Statewide Efficiency Standards

By setting minimum efficiency standards for commonly sold products like exit signs, ceiling fans, and traffic lights, New Jersey can shave 300 MW off peak demand by 2010, and save consumers $1.8 billion dollars by 2020. The state should quickly adopt this common sense policy so that New Jersey can decrease its need for risky sources of power like Oyster Creek.

Appendix: Untapped Renewable and Energy Efficiency Resources in PJM Grid

WIND ENERGY POTENTIAL IN PENNSYLVANIA, NEW JERSEY, AND MARYLAND

PJM reports that nearly 1,200 MW of wind energy projects are currently in some stage of development in the region. A list of such projects can be found in Table A1.

For the moment, however, the region's wind resources are largely undeveloped. If wind power potential in Pennsylvania, New Jersey, and Maryland is fully developed, it could yield more than 6,000 MW (average) for the region, enough to both replace Oyster Creek's generating capacity and meet future demand, combined. (See Table A2.)[115]

Pennsylvania

Table A2. Regional Wind Capacity

State	MWa
Pennsylvania	5,120
Maryland	338
New Jersey	1,200
Total	**6,658**

Pennsylvania is now one of the leading states in the region for wind power development. Although Pennsylvania's current wind energy facilities have a maximum output of only 34.5 MW, 170 MW of wind capacity are expected to come online in the state over the next two years, enough to supply an additional 50,000 households. Pennsylvania's wind energy resources have the potential to produce 5,120 MW (average) of electricity, or 45 billion kilowatt-hours per year.

New Jersey

New Jersey's wind potential is primarily located in the northwestern corner of the state, from the Highlands region of Warren County to the Pennsylvania border, and along the coast. According to the United States Department of Energy's own estimates, approximately 8% of New Jersey's land has good wind resources and is available for development.[116] The Pacific Northwest Laboratory estimated that New Jersey's wind resources, if developed, could have a 1,200 MWa capacity. As Table 8 shows, at the moment only 7.5 MW of wind power are in development, far below the state's potential.

Table A1. Wind Energy Projects in Development in PJM Region

Project	MW	Expected Online	State
Hooversville 115kV	30	2003	PA
E Carbondale (Wind)	70	2003	PA
Somerset 115kV (Wind)	30	2003	PA
Myersdale North	48	2003	PA
Somerset-Allegheny 115kV	45	2003	PA
Bear Creek 69kV	34	2003	PA
Ontario 23kV	8	2003	NJ
Kelso Gap	100	2003	MD
Savage	40	2004	MD
Total in Development	**405**		

Maryland

Although Maryland's wind potential is not as high as Pennsylvania's, one of the largest wind energy facilities planned for the region is the Kelso Gap project in Maryland. This will consist of 67 turbines on a ridge-top site on Backbone Mountain in Garrett County, and is projected to provide up to 101 MW of clean energy.[117]

SOLAR POWER

Solar power is a valuable, and effectively unlimited, resource for New Jersey. Current solar PV average capacity in the state stands at over 7.4 MW, a dramatic increase from the 71 kW online in the state just four years ago.[118]

Solar cells are especially productive on the same hot summer days that set air conditioning use, and therefore electricity demand, skyrocketing. Because peak demand is much higher than base load needs and energy at peak demand can be more than twice as expensive as it is at other times, every megawatt of installed solar capacity has special value in terms

Spotlight on New Jersey: New Wind in the Works for New Jersey

Although New Jersey's wind resources are currently untapped, this winter the New Jersey Board of Public Utilities announced funding for several wind energy projects. This funding included a $1.7 million state grant for a 7.5 MW coastal wind farm outside of Atlantic City, projected to open in late 2003.

Other wind farm projects in the works for New Jersey include:

- Scotts Mountain: Clipper Windpower received a $3.1 million state grant to build a 21 MW $25 million wind farm in Warren County. The estimated completion date is late 2004.
- Springfield: A Community Energy wind farm that could be completed by 2005 is in the preliminary stages of development.
- The Shore: Atlantic Renewable Energy got $300,000 from the state to study the feasibility of a 25 MW offshore wind farm to be built between Sandy Hook and Cape May by 2006.
- Cumberland County: A Community Energy wind farm at a state facility is in early development. It could be built by 2004.

of its ability to displace traditional petroleum-based or coal-fired generators and keep electric rates in check.

The capital cost of installing solar power is the biggest inhibitor to development of this resource. In New Jersey, where electricity rates are high (11.4¢/kWh),[119] solar PV systems are cost-competitive in the energy market today over a span of several years. These systems are particularly cost-effective when incorporated into the design of buildings before their construction. New Jerseyans who purchased solar systems at 1999 prices will realize a $2,819/kW net savings over the lifetime of the system.[120]

The Board of Public Utilities recently voted to fund a demonstration project in which photovoltaics will be installed on 40 to 50 individual roofs and gas systems.[121] If similar solar panels were incorporated in ten percent of new residential development, more than 20 MW of solar power could easily come online each year in New Jersey.

BIOMASS

The National Renewable Energy Lab estimates that 1.4 million MWh of electricity could be generated in New Jersey using five general categories of biomass fuels: urban residues, mill residues, forest residues, agricultural residues, and energy crops. This is enough electricity to fully supply the annual needs of 142,000 average homes, or 7 percent of the residential electricity use in New Jersey.

Another analysis of New Jersey's biomass potential presented in the Energy Information Administration's "*Annual Energy Outlook 2001*" identified the net summer generating capacity from biomass potential in New Jersey to be 650.9 MW between 2003 through 2016, roughly equivalent to the capacity of Oyster Creek Nuclear Power Plant.

Table A3. Regional Biomass Capability

State	MW
Pennsylvania	256
Maryland	120
New Jersey	176
Total	**532**

Yet not all this biomass potential should be developed. The only clean, renewable sources of biomass are plant materials and nonhazardous waste derived from plants, such as agricultural byproducts or tree trimmings, gasified animal waste, and some kinds of landfill methane. Any biomass combustion should meet the best available emission control technologies.

Preference should be given for gasified biomass technologies.

LANDFILL GAS

Landfill gas can be considered one kind of biomass energy. In New Jersey, landfill gas collection and combustion projects currently exist with 153 MW of generating capacity. A report by Xenergy has projected the total landfill gas capacity in New Jersey to be as high as 267 MW.

Burning landfill gas to produce energy can emit more pollution per kilowatt hour than natural gas does.[122] Therefore, while the use of landfill gas to generate electricity can have a net benefit for the environment, landfill gas cannot be considered a clean fuel unless the gas is first filtered so that toxic halogenated compounds are segregated.

Once filtered out, these compounds should not be combusted. They should be handled as hazardous waste and isolated from the environment as best as is possible until there is a proven technology that can neutralize the toxics by converting the halogens to relatively harmless chemicals like salts.[123]

New Landfill Gas Powering New Jersey[124]

Two landfill gas projects have recently received funding from the New Jersey BPU:

- **Essex and Union Joint Meeting wastewater treatment facility—**First Energy Solutions in Elizabeth, NJ received $2 million to pilot a prototype sludge digestion process in which 2.94 MW will be generated by methane gas.

- **Aluminum Shapes/Pennsauken Landfill—**Aluminum Shapes received $2.39 million to develop two gas collection systems to generate 5.7 MW of electricity from the adjoining Pennsauken Landfill.

GEOTHERMAL

Although there are no high temperature geothermal resources capable of producing electricity in New Jersey, the state has ample geothermal resources for use of geothermal heat pumps, which reduce demand for electricity. The New Jersey Board of Public Utilities recognized the value of this geothermal resource. In 2000, the U.S. Department of Energy and the New Jersey Board of Public Utilities conducted a comprehensive outreach program to inform school officials about geothermal heat pump technology.[125] New Jersey Department of Environmental Protection officials are also promoting the use of geothermal heat pumps in state parks such as Monmouth Battlefield State Park, which is currently using geothermal energy in their visitors center. Widespread use of these systems could play a major role in reducing electricity demand in the state.

ENERGY EFFICIENCY

Energy efficiency measures are the most effective tool for New Jersey to decrease its use of nuclear power and fossil fuels and the pollution that accompanies them.

Energy efficiency is also the only way to slow projected increases in electricity demand. New Jersey's transmission system will require costly upgrades if electricity demand increases significantly. In addition to reducing the state's dependence on dangerous power from fossil fuels and nuclear power plants, energy efficiency can help save state residents, businesses, and industry hundreds of millions of dollars.

An Important Energy Efficiency Program: Appliance Standards

Energy efficiency standards for ten common appliances, such as ceiling fans and clothes washers, are currently under consideration by state decisionmakers.

Raising appliance standards in New Jersey would reduce energy consumption by 1300 Gigawatt-hours (equivalent to the energy needed by almost 2 % of the state's households in 2000) resulting in net savings of over $260 Million dollars to businesses and consumers through 2010. This is roughly equivalent to replacing 148 MW capacity power plant operating 100% of the time, and would shave roughly 300 MW of peak demand by 2010.

By 2020, the proposed energy efficiency standards will reduce peak demand by over 500 MW, the equivalent of 2 mid-sized power plants or 3% of the state's generating capacity.

Another Example of Untapped Energy Efficiency Potential: Building Codes

One of the many ways New Jersey could improve energy efficiency would be by adopting a stronger building code. New Jersey was ranked eighth in the nation for total energy savings potential attainable from adopting stricter building codes.[126] According to the Alliance to Save Energy, a single-family home in New Jersey built in accordance with the 1993 International Code Council's Model Energy Code would experience considerable savings compared to a single-family home built under current building codes. An initial investment of $2,100 per single-family home to meet the stricter building code would yield:

- A first year savings in energy costs of $200, with a positive cash flow in 3.2 years.
- Annual energy savings of 4,570 kWh.
- Annual reduction of 1-1.5 tons of greenhouse gas emissions.[127]

At the above projected annual energy savings per home and assuming the current new home construction rate in New Jersey of 30,000 new homes built each year, adopting such building codes would help displace 16 MW of installed capacity this year, and over the course of ten years, 160 MW.[128]

Combining utility energy efficiency programs with other cost-effective programs targeting sectors like the appliance and building industries would yield the best results. The American Council for an Energy-Efficient Economy analyzed the impacts of energy efficiency investments in the mid-Atlantic region (New York, Pennsylvania, and New Jersey) for 1997-2010. They concluded that the region could cut its electricity consumption by 33% in that thirteen-year period.[129]

Notes

1. Both the reality and magnitude of this risk is evident by the Price-Anderson Act passed in 1957 to provide federal liability protection against a nuclear plant accident. No other commercial endeavor requires such federal liability protection. The US Congress is currently considering extending Price-Anderson because the risks have not subsided.

2. In fact, the plant was originally licensed to operate for 35 years. This license was extended on July 2, 1991.

3. Nuclear Age Peace Foundation, "Nuclear Waste," Nuclearfiles.org, 2002.

4. US Department of Energy, Energy Information Administration, "Spent Nuclear Fuel Discharges from U.S. Reactors 1992," May 1994, Washington, DC, Table 4.

5. US Department of Defense and US Department of Energy, "Fission Products," *The Effects of Nuclear Weapons*, 3rd edition, 1977, as cited in Dr. Rosalie Bertell, *No Immediate Danger: Prognosis for a Radioactive Earth,* The Book Publishing Company, Summertown, Tennessee.

6. Adapted from Nuclear Regulatory Commission, "The Boiling Water Reactor," www.nrc.gov/reading-rm/basic-ref/students/animated-bwr.html.

7. See note 3.

8. Chris Busby, Rosalie Bertell, et al, European Committee on Radiation Risk, *"Recommendations of the ECRR: The Health Effects of Ionising Radiation Exposure at Low Doses for Radiation Protection Purposes,"* 2003.

9. University of California, San Francisco, "Units for Measuring Ionizing Radiation," *Radiation Training Manual, 1997.* The rad is being replaced by a different unit equivalent to 100 rads called the Grey.

10. For a more extensive description of reactor coolants, please see www.nucleartourist.com/basics/construct.htm.

11. Dr. Rosalie Bertell, *No Immediate Danger: Prognosis for a Radioactive Earth,* The Book Publishing Company, Summertown, Tennessee.

12. Ibid.

13. Nuclear Age Peace Foundation, "Nuclear Waste," Nuclearfiles.org, 2002.

14. John W. Gofman, Ph.D., M.D., and Arthur R. Tamplin, Ph.D., *Poisoned Power: The Case Against Nuclear Power Plants Before and After Three Mile Island,* Rodale Press, Emmaus, PA, 1979. www.ratical.org/radiation/CNR/PP/chp8.html.

15. Joseph J. Mangano, "Improvements in Local Infant Health After Nuclear Power Plant Closing," Environmental Epidemiology and Toxicology, 2, 32-36, 2000.

16. Nuclear Age Peace Foundation, "Nuclear Waste," Nuclearfiles.org, 2002.

17. Arjun Makhijani, "More than 40,000 Tons A Bad Approach To Nuclear Waste," *Washington Post,* 13 February 2002, p. A27.

18. Nuclear Information and Resource Service, *U.S. Nuclear Debt Clock,* using information from the U.S. Department of Energy, downloaded from www.nirs.org/dontwasteamerica/Nukedeb1.htm, 28 April 2001.

19. Energy Information Administration, Form RW-859, "Nuclear Fuel Data" (1998).

20. U.S. Department of Energy Office of Civilian Radioactive Waste Management, Office of Environmental Restoration and Waste Management by Oak Ridge National Laboratory, "Revision 12 of the Integrated Data Base (IDB) Report (document DOE/RW-0006)."

21. Robert Alvarez, "What About Spent Fuel?" *Bulletin of the Atomic Scientists,* January/February 2002, Vol. 58, No. 1, pp. 45-47.

22. Ibid.

23. U.S. Department of Energy, "Statement of Position In the Matter of Proposed Rulemaking on the Storage and Disposal of Nuclear Waste (Waste Confidence Proceeding)," Docket PR-50,51(44 FR61372), before the U.S. Nuclear Regulatory Commission, DOE/NE-0007, 15 April 1980.

24. Colin Woodard, "Decommissioning: Remember the Maine Yankee," *Bulletin of the Atomic Scientists*, January/February 2001, Vol. 57, No. 1, pp. 11-19.

25. **"**Ferguson Votes To Remove Nuclear Waste From New Jersey," 8 May 2002, www.house.gov/ferguson/press/20020508.shtml.

26. See note 24.

27. Nuclear Energy Institute, "Common Objections to the Yucca Mountain Project: What the Science Really Says," 2003.

28. Ibid.

29. Based on conversion factors derived from Department of Energy's "Final Programmatic Environmental Impact Statement for Tritium Supply and Recycling (DOE/EIS-016l)," October 1995.

30. Nuclear Energy Institute, "Nuclear Power in New Jersey," www.nei.org/documents/States_NJ.pdf.

31. Matthew Bunn, John P. Holden, et al. *Interim Storage of Spent Nuclear Fuel: A Safe, Flexible, and Cost-Effective Near-Term Approach to Spent Fuel Management*, Managing the Atom Project, Harvard University, Cambridge, MA, and Project on Sociotechnics of Nuclear Energy, University of Tokyo, 2001.

32. Correspondence with Kent Tosch, Manager, Bureau of Nuclear Engineering, New Jersey Department of Environmental Protection, 17 December 2002.

33. United States Nuclear Regulatory Commission, "Alternative Requjrements For Fuel Assemblies In Design Features Section Of Technical Specifications (Generic Letter 90-02)," Washington, D.C. 20555, 1 February, 1990.

34. Karen Sudol, "Oyster Creek Completes Move Of Spent Fuel To Concrete Vaults," *Asbury Park Press*, 22 May 2002.

35. Adam Serchuk, "The Environmental Imperative for Renewable Energy: An Update," Renewable Energy Policy Project, 2000.

36. Public Citizen, "Impacts of Nuclear Waste Transportation," 2 September 2001.

37. Dr. Marvin Resnikoff, Radioactive Waste Management Associates, as cited in U.S. PIRG's *Radioactive Roads and Rails: Hauling Nuclear Waste Through Our Neighborhoods*, June 2002.

38. See note 36.

39. Bob Ivry and Alex Nussbaum, "Hot Cargo: Transport of Nuclear Waste Awaits Approval," *The Bergen Record*, A01, 28 April 2002.

40. Public Citizen, "New Jersey Nuclear Waste Transport Routemaps," 6 May 2002.

41. State of Nevada Agency for Nuclear Projects, "Highway, Rail and Barge Routes To Yucca Mountain," May 2002, www.state.nv.us/nucwaste/maps2002/roadrail/.

42. North American Technical Center, Prepared for Scientific Studies in North America, Europe, Asia, and UNSCEAR, Department of Nuclear, Plasma, and Radiological Engineering, College of Engineering, University of Illinois at Urbana-Champaign, 2001.

43. Calculated from Oyster Creek's Annual Emissions summaries posted at www.nrc.gov.

44. Nuclear Information Resource Service Factsheet, "Routine Radioactive Releases From Nuclear Reactors - It Doesn't Take An Accident !"

45. Union of Concerned Scientists, "Backgrounder: How Nuclear Power Works," 11 February 2003.

46. Energy Information Administration, Form EIA-858, "Uranium Industry Annual Survey," 2001.

47. Institute for Energy and Environmental Research, "Annual Radioactive Waste Generation Per Reactor," May 2000.

48. Nuclear Regulatory Commission, "Fact Sheet on Uranium Mill Tailings," February 2002.

49. The Project on Government Oversight. "Moab Uranium Tailings Factsheet," 24 May 2000.

50. Beat Hintermann, Marilynn de la Merced and Marvin Resnikoff, "Groundwater Movement at the Portsmouth Gaseous Diffusion Plant," Radioactive Waste Management Associates, February 2002.

51. Linda Ashton, "State Warns of Suit over Hanford Cleanup," *Seattle Times*, 24 March 2001.

52. Brian G. Chow and Gregory S. Jones, "Annual Radioactive Waste Generation Per Reactor: Low Enriched Uranium Once Through (LEU-OT) and Mixed-Oxide Once Through (MOX-OT) Cycles," *Managing Wastes With and Without Plutonium Separation*, Santa Monica, CA, RAND, 1999. All waste volumes are in cubic meters per Gigawatt electricity-year (m3/GWe-yr).

53. Ibid.

54. Dr Nigel Mortimer, *Friends of the Earth 9*, 1989.

55. US House of Representatives, Committee on Interior and Insular Affairs Subcommittee on Oversight & Investigations, "Calculation of Reactor Accident Consequences (CRAC2) for US Nuclear Power Plants (Health Effects and Costs) Conditional on an 'SST1' Release," 1 November, 1982, as cited by David Lochbaum, Nuclear Safety Engineer, Union of Concerned Scientists.

56. David Lochbaum, Union of Concerned Scientists, *Nuclear Plant Risk Studies: Failing the Grade*, Cambridge, MA, August 2000), downloadable at www.ucsusa.org/energy/nuc_risk.html.

57. CNN, "Chernobyl Survivors Recall A Decade of Death and Denial," 26 April, 1996, www.cnn.com/WORLD/9604/26/chernobyl/230pm/.

58. Arjun Makhijani, "Nuclear Power: No Solution to Global Climate Change," Institute for Energy and Environmental Research, 11 December 2002.

59. Richard L. Hudson, "Cost of Chernobyl Nuclear Disaster Soars in New Study," *Wall Street Journal*, 29 March 1990, page A8.

60. Ellsworth Weaver III, "A Brief Chronology of Radiation and Protection,"1995, www.umich.edu/~radinfo/introduction/chrono3.html.

61. Derived from DOE and US Army records, as cited in www.radiationworks.com/sl1reactor.htm.

62. A Stanley Tompson, “Comments On Nuclear Power,” www.ratical.org/radiation/CoNP/.

63. Ibid.

64. “Davis Besse’s Near Miss,” *Cleveland Plain Dealer*, October 2002, on the web at www.cleveland.com/davisbesse/agate.ssf?/davisbesse/102002.html.

65. David Lochbaum, “Everything You Know Is Wrong: Fission Stories: Nuclear Power’s Secrets,” 18 May 2002.

66. Steve Nichols, senior evaluator in Institute of Nuclear Power Operations’ engineering department, presentation at a conference in 2000, as cited by Stephen Koff, “Nuclear Plant Equipment Problems Worsening as Reactors Age,” Newhouse News Service, 9 December 2002.

67. Stephen Koff, “Nuclear Plant Equipment Problems Worsening as Reactors Age,” Newhouse News Service, 9 December 2002.

68. Dennis J. Wilkins, “The Bathtub Curve And Product Failure Behavior Part One—The Bathtub Curve, Infant Mortality And Burn-In,” *Reliability Hotwire*, Issue 21, November 2002.

69. Susan Q Stranahan, “Reactor Revival; Old Reactors Being Re-licensed,” *Mother Jones*, November 2001.

70. United States Nuclear Regulatory Commission, Information Notice 95-17, “Reactor Vessel Top Guide and Core Plate Cracking,” 10 March, 1995, and UREG/CR-6677-01 “Evaluation Of Risk Associated With Intergranular Stress Corrosion Cracking In Boiling Water Reactor Internals.”

71. Paul Gunter, Nuclear Information and Resource Service, “Hazards of Boiling Water Reactors in the United States,” July 1996.

72. Ibid.

73. “Inside N.R.C.: An exclusive report on the U.S. Nuclear Regulatory Commission,” McGraw Hill, Vol. 8, No. 12, 9 June 1986.

74. See note 71.

75. Physicians for Social Responsibility, “Issue Brief: Vulnerability of US Nuclear Power Plants to Terrorist Attack and Internal Sabotage,” Center for Global Health and Security. Retrieved July 19, 2002, from www.psr.org/s11/plants.html.

76. See note 21.

77. Ibid.

78. Project on Government Oversight, “Voices from Inside the Fences,” 12 September 2002.

79. Ibid.

80. “Proposed Director’s Decision Under 10 Cfr 2.206 Petition On Spent Fuel Dry Cask Storage At Oyster Creek Nuclear Generating Station,” 10 December 2002, NRC Director Responding to Edith Gbur.

81. See note 21.

82. Brookhaven National Laboratory for U.S. Nuclear Regulatory Commission, “A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants,” August 1997.

83. Prepared for the U.S. Nuclear Regulatory Commission by Brookhaven National Laboratory, “A Safety and Regulatory Assessment of Generic BWR and PWR Permanently Shutdown Nuclear Power Plants,” NUREG/CR-6451 BNL-NUREG-52498, August 1997, Executive Summary, p. ix, p. 4-3.

84. Nuclear Regulatory Commission, “Technical Study of Spent Fuel Pool Accident Risk at Decommissioning Nuclear Power Plants,” October 2000.

85. J. J. Curry Sc.D., P.E., Mgr. Decommissioning Engineering, Oyster Creek Nuclear Generating Station, “Planning For The Early Retirement Of The Oyster Creek Nuclear Generating Station —Engineering Issues,” WM ’99 Conference, February 28 - March 4, 1999.

86. Ibid.

87. Union of Concerned Scientists, “Davis-Besse Retrospective,” 3 March 2003.

88. Utility Business Staff, “Protests Don’t Stop Nuclear Plant Relicensing,” Utility Business, 1 July 2000.

89. Micah Lowenthal, “International Profiles on Radioactive Waste and Radioactive Waste Disposal Programs,” University of California, Berkeley, 27 September 1995.

90. Office of Science and Technical Information, “Historical Records Of The Atomic Energy Commission,” www.osti.gov/opennet/nsi_desc.html.

91. Brian Faler, “Workers Question NRC’s Pledge on Safety,” *Washington Post*, 9 January 2003.

92. As cited in Project on Government Oversight, “Who The Hell Is Regulating Who? The NRC’s Abdication Of Responsibility,” September 1996.

93. This section summarizes a document written by Paul Gunter and David Lochbaum, “Anatomy of a Flawed Decision: NRC Has a Brain, But No Spine,” 5 August 2002.

94. See note 92.

95. Ibid.

96. David Lochbaum, Union of Concerned Scientists, "Nuclear Plant Risk Studies: Failing the Grade," August 2000.

97. Public Citizen, "Amnesty Irrational," Critical Mass Energy Project, 1 August 1999.

98. New Jersey Transportation Planning Authority, "Mobility Matters, Transportation Issues in the NJTPA Region. An Ongoing Challenge: Getting to the Shore." Retrieved from www.njtpa.org/public-affairs on March 15, 2003.

99. Tara Servatius, "Pills and PR: Officials, get serious about nuclear evacuations," *Charlotte Creative Loafing*, October 2002.

100. NJ BPU.

101. See note 30.

102. Energy Information Administration, "Electricity InfoCard 2000," 6 May 2002.

103. Energy Information Administration, "Electric Power Annual 2000, Volume 1," 2000.

104. Source: PJM Interconnection L.L.C., "Existing Generator Data, as of Jan. 1, 2002," www.pjm.com.

105. PJM Interconnection L.L.C. Based on analysis of data presented in "2000 Annual Report on Operations," www.pjm.com/performcompli/operations/reports/annual_report_on_operations_2000.pdf.

106. Ibid.

107. See Appendix A for a list of natural gas projects in development in New Jersey.

108. Nuclear Energy Institute, as cited by www.pbs.org/wgbh/pages/frontline/shows/reaction/maps/chart2.html.

109. R. William Potter, "In The Matter Of The Review To Evaluate And Make Recommendations Concerning The Statewide Administration Of Energy Efficiency And Customer-Sited Renewable Energy Programs," BPU Docket #EX01070447.

110. Nadel, et al, ACEEE, *Energy Efficiency and Economic Development in New York, New Jersey, and Pennsylvania,* February 1997.

111. Based on growth projections of the New Jersey utilities in: PJM Interconnection L.L.C., The Load Analysis Subcommittee, *PJM Load Forecast Report*, February 2001.

112. Assuming the standard 33% capacity factor for wind power generation.

113. New Jersey Clean Energy Task Force draft data.

114. Wind energy potential figures cited for each state are from *An Assessment of the Available Windy Land Area and Wind Energy Potential in the Contiguous United States*, Pacific Northwest Laboratory, 1991, as cited by American Wind Energy Association in cooperation with the U.S. Department of Energy, *An Inventory of State Incentives for the U.S.: A State by State Survey*, 2002.

115. US Department of Energy, "New Jersey State Energy Information, " 13 March 2003.

116. Clipper Windpower Inc., "Facts About Wind Energy and the Criterion Project," 2002.

117. NJDEP Renewable Energy Model, based on reports from the New Jersey Clean Energy Program, 20 March 2003.

118. U.S. EIA, *U.S. Electric Utility Average Revenue per Kilowatt-hour (Retail Price) Data, Table 14: Class of Ownership, Number of Ultimate Consumers, Revenue, Sales, and Average Revenue per Kilowatthour for the Residential Sector by State and Utility 1999*, downloaded from www.eia.doe.gov/cneaf/electricity/page/at_a_glance/sales_tabs.html, 23 December 2001.

119. National Renewable Energy Laboratory, *Customer Sited PV — U.S. Markets Developed from State Policies*, May 2000, as analyzed in NJPIRG Clean Energy Solutions.

120. NJPIRG Law & Policy Center, "Clean Energy Solutions," 2002.

121. "Methodologies for Quantifying Pollution Prevention Benefits from Landfill Gas Control and Utilization," EPA document #600SR95089, July 1995.

122. Mike Ewall, "Primer on Landfill Gas as 'Green' Energy, Part Four of Pennsylvania Environmental Network's series on Green Energy," 10 February 2000.

123. New Jersey BPU, "New Jersey Board Of Public Utilities Approves Large Renewable Energy Projects," Newark, NJ, 8 January 2003.

124. U.S. DOE, EREN, *State Energy Program*, 23 December 2001, downloaded from www.eren.doe.gov/buildings/state_energy/projects/cfm/states.

125. The Alliance to Save Energy, *Opportunity Lost*, 1998.

126. Ibid.

127. This new home construction value would be lower than the number of homes built during the 90s boom but similar to new home construction in 2001 and 2002. Based on figures cited by Richard Newman, "Sales of new homes hit record; But Northeast market slumps," *The Bergen Record*, 28 December 2002.

128. See note 110.