Washington Internships for Students of Engineering

Preparing Public Confidence: Setting the Stage for Generation IV Reactors

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About the Author

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About WISE

The Washington Internships for Students of Engineering (WISE) program brings engineering students from diverse backgrounds to Washington, D.C., to learn about the interface between science, technology, and policy. While learning about this relationship, students have the opportunity to visit numerous federal agencies and organizations in the Washington, D.C., area. Participants have the opportunity to select a topic of interest to them to research for the summer. Through personal interviews, basic research, and agency contacts, students are able to gain a political perspective on a technical topic. Students then convey their research efforts through a written report and oral presentation at the conclusion of the ten weeks.

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Abstract

Nuclear power currently produces approximately 20% of electricity in the United States, and many believe that nuclear electricity is an environmentally friendly and economic energy option. In response to a new need and desire for nuclear power, the United States Department of Energy (DOE) Office of Nuclear Energy, Science and Technology is currently developing an initiative to bring a new generation of nuclear reactors online. However, the U.S. DOE's Nuclear Energy Research Initiative suggests that new nuclear plants will not be accepted by the public until it is evident that the government and the industry are taking measures to resolve public concerns. Is public confidence necessary for a rebirth of nuclear energy? The public opinion timeline over the life of nuclear energy indicates that an increase in public opinion is crucial for this renaissance to take place. The issues at the heart of public concern with regard to nuclear power generation are: waste disposal, reactor safety, economics, and non-proliferation. These concerns have been addressed recently via: pending legislation, education programs, and industry programs. The passage of this legislation as well as continued education, public/industry relations, and research and development is needed in the near future in order to create a renewed image of nuclear power as an up-to-date, dynamic, beneficial industry in preparation for a new generation of nuclear reactors in the United States.

Preparing Public Confidence: Setting the Stage for Generation IV Reactors

Introduction

Nuclear power currently produces approximately 20% of electricity in the United States. However, recent energy issues and the near crisis in California may allow nuclear power to have a higher stature in America's energy mix. In response to a new need and desire for nuclear power, the United States Department of Energy (DOE) Office of Nuclear Energy, Science and Technology is currently developing an initiative to bring a new generation of nuclear reactors online. The Generation IV Initiative aims to develop technologies that achieve safety performance, waste reduction, and proliferation resistance while providing a nuclear energy option that is economically competitive and ready for deployment before 2030.[1] A recent proposal by the U.S. DOE's Nuclear Energy Research Initiative suggests that new nuclear plants will not be accepted by the public until it is evident that the government and the industry are taking measures to resolve economic, safety, waste management, and proliferation concerns.[2] The purpose of this report is not to deal with the technical aspects of the Generation IV Initiative. Instead the objective is to establish the importance of public confidence in the effort to create a flourishing nuclear power industry in the United States.

Is public confidence necessary for a rebirth of nuclear energy to take place? Some say that the fate of nuclear power falls subject only to the stringent regulatory environment that surrounds the industry. To people with this mindset, an effort to increase public confidence in the nuclear industry would be futile. In this case, only the position of the current administration and the workings of the regulatory structure should be taken into account. The policy goals of

the current administration are important, and another driving force for new legislation in America is the Congress. In a representative democracy such as the United States, these members of Congress are chartered to represent the views and feelings of their constituents. It is chiefly for this reason that public confidence in the nuclear industry should, in fact, remain a concern for policy makers, the current administration, and those who would like to see nuclear power considered a viable energy option in the future.

Public Opinion Timeline

When the first U.S. nuclear power plant began operating at the Shippingport Atomic Power Station in Pennsylvania in 1958, few voices were raised in protest.[3] In fact, many welcomed the thought of using the atom for peaceful purposes as opposed to the destructive uses that had been introduced with the atomic bomb in 1945. This positive environment of public confidence was greatly because of Eisenhower's Atoms for Peace program that began in 1956 as a conscious response to the growing controversy over atomic testing. Local opposition to the building of nuclear power facilities came in 1961 with Pacific Gas and Electricity Company's plans for the Bodega Head plant north of San Francisco.[4] When it was discovered by the public that Pacific Gas and Electric had plans to construct their nuclear plant within a local nature reserve near an earthquake fault, the Sierra Club, an ecological group, was motivated to adopt an anti-nuclear attitude. This movement continued to gain force with Pacific Gas and Electric's Malibu Beach nuclear power site for the same reasons. Soon after the case made at Bodega Head and Malibu Beach, opposition originally focused on site-specific complaints became integrated into a broader case against the nuclear industry in general. Early local conflicts were

centered on the issue of thermal pollution. At that time, nuclear plants did not use cooling towers. Instead, utilities opted for sites on lakes, oceans, or rivers that allowed "once through cooling."[5] Fishermen, the tourism industry, and conservationists became concerned that this thermal pollution into lakes and streams could have adverse effects on the water ecology. These objections documented the first local opposition to the nuclear power industry and stimulated public interest in many other issues.

By 1970, the potential health effects of routine radioactive emissions became a focus of public concern.[6] These concerns made their public debut as part of the environmental emphasis of Earth Day in 1970. Following this event, a massive rise in media coverage of nuclear issues took place. In fact, an analysis by Rankin and Nealy revealed that newspaper and magazine coverage of nuclear power underwent a fivefold increase between 1972 and 1976.[7] The major turning point for public confidence in the nuclear power industry came in 1979 with the accident at Three Mile Island. During the first two weeks after the accident, the event received more television coverage than during all the years since the atom was split.[8] Many people believe that the Three Mile Island accident caused significant damage to the public's opinion of nuclear power, and that this damage simply could not be mended. Actually, as a result of slowing load growth, no new plants had been ordered since as much as five years before the Three Mile Island incident. By the end of 1982, one hundred nuclear units had been cancelled by utility companies, totaling 109,754 MWe of power.[9]

The decline in public confidence in nuclear power from the 1950's to the present has not only been caused by newspapers, magazines, and network news reports. Hollywood has taken its own swing at the industry. The first popular anti-nuclear movie plot involved the idea of nuclear warfare. As early as 1945, movies such as First Yank Into Tokyo identified nuclear

warfare as a story line sure to invoke fear in the American people. From there, many radioactive spills and accidents were a cause for alarm in many fictitious towns. The Horror of Party Beach in 1964 depicted numerous creepy monsters that invaded the surf of a dreamy Connecticut beach when radioactive waste dumping went awry. The China Syndrome in 1979 starred Jane Fonda and Michael Douglas. In the movie, these two main characters inadvertently film an accident taking place at a nuclear power plant and confront the industry's cover-up. The title refers to nuclear jargon for the worst conceivable reactor accident: the reactor core overheats and melts through the plant floor, theoretically all the way through the earth to China. This movie had a magnified impact on public confidence in the nuclear industry because it was released in the same year that an accident occurred at the Three Mile Island nuclear facility. Coincidentally, the accident occurred when the reactor core in the Three Mile Island Unit Two reactor overheated, which seemed very similar to the accident portrayed in the film. The Children in 1980 portrayed a rather interesting plot in which toxic gas from a nuclear power plant infiltrated a school bus, giving the school children a weird symptom: anyone they hugged burned up. Some movies and theatrical productions even called upon famous musicians and artists who would support anti-nuclear shows. For example, the 1980 production No Nukes featured a cast including Bruce Springsteen, Jane Fonda, Carly Simon, and The Doobie Brothers.[10]

The Issues

Somewhat surprisingly, the areas of concern with regard to the nuclear industry have not changed much over the years. An overwhelming majority of the books and articles reviewed during research for this report cited the same key issues of concern: waste disposal, reactor

safety, economics, and non-proliferation. The order listed previously is often considered the descending ranking of importance as far as the public is concerned. Many anti-nuclear critics would reverse the order, according to Dr. Thomas Cochran of the Natural Resources Defense Council.[11] It is important to expand upon these issues in order to discover the heart of the public confidence concern. It appears that the Department of Energy understands that these key issues are driving public confidence and in response has fashioned the Generation IV Initiative to specifically address these issues.

Background: The Generation IV Initiative

The Generation IV Initiative was developed by the Department of Energy's Office of Nuclear Science and Technology in order to address the need in many countries for nuclear power to gain influence in the effort to meet future energy needs.[12] The goal of the Generation IV initiative is to work on an international basis to identify, assess, and develop sustainable nuclear energy technologies that can be licensed, constructed, and operated in a manner that will provide a competitively priced supply of energy. The initiative also aims to satisfactorily address nuclear safety, waste, proliferation resistance, and public perception concerns of the countries in which these nuclear technologies are deployed. Generation IV aspires to engage governments, industry, and the research community worldwide in the development of the next generation of nuclear reactors. The past three generations of nuclear reactors are classified as follows:

- Generation I: Prototypes
- Generation II: Current operating plants
- Generation III: Advanced light water reactors

The Generation II and III nuclear power plant designs are still considered to provide acceptable electricity supply, but the Department of Energy sees the need to research further advances in reactor technology in order to expand the opportunities for nuclear energy in the near future. The first step in this technology development is to create a Technology Roadmap to direct Generation IV research and development. For fiscal year 2001, Congress appropriated $4.5 million to begin the roadmap venture. The anticipated end product of the Generation IV Initiative will be at least one next-generation nuclear reactor design certified by 2030. It is also important to note that industry is evaluating possibilities for a sooner deployment of reactors that will fall under the Generation III or perhaps Generation III+ category. This is suspected to take place prior to the 2030 date spoken of for Generation IV reactors. Also, in order for Generation IV reactors to be up and running by 2030, the licensing of sites and reactor designs should be completed closer to 2020 or before.

The issues referenced in the Generation IV Initiative with regard to public confidence are precisely the issues that will be addressed in this report. For the purpose of this report, the following sections are ordered by descending importance in reference to how most of the public ranks the issues.

Waste Disposal

Richard Rhodes and Denis Beller in their article "The Need for Nuclear Power" assert that "nuclear waste disposal is a political problem in the United States because of widespread fear disproportionate to the reality of risk."[13] A similar comment was made by Gerald Marsh, a physicist and program manager at Argonne National Laboratory and prior consultant to the Office of the Chief of Naval Operations. He commented in an article to the Bulletin of the

Atomic Scientists that "much of the problem with nuclear waste disposal is political and perceptual, not technical."[14] Surveys by the Batelle Human Affairs Research Centers in the 1980's showed that leakage of liquid waste from storage tanks and the possibility that water will enter a waste repository are found to be of greatest concern to the public.[15] The commercial waste issue does not include storage of commercial fuel in liquid form—only in solid form. However, water infiltration and leaching of the waste into groundwater is a concern of geological waste repositories.

Most members of the public know that the nuclear fission process is common to nuclear weapons and nuclear reactors. Even though many tend to accept that reactors are well controlled, members of the public fear the chance of release of radioactivity, and nuclear waste is a tangible substance to direct this fear toward. Radiation is a danger that the public cannot see, touch, hear, smell, or taste; however, anyone can see trucks of nuclear waste driving through his or her town, and they can see waste piling up in dry storage casks. Therefore, it is no wonder why waste disposal is the issue at the top of the list of public concern over nuclear power.

Nuclear waste consists of material with low and high levels of radioactivity. Low-level wastes (LLW) obtain their name due to the fact that their associated radioactivity level is very small. Filters that have been used to remove radioactive debris from air or water, cleaning utensils, gloves, laboratory equipment, and instrument components are all typical items in the LLW category.[16] The radioactive concentration of LLW is about one billionth of that for high-level wastes (HLW). Therefore, one can imagine why most of public concern evolves around HLW. HLW is generated from the fission process in nuclear power reactors. The fission products causing the radioactivity are produced as the nuclear fuel undergoes nuclear fission. This HLW is often referred to as *spent fuel*. These terms are often used interchangeably, but not

all HLW is found in the form of spent fuel. The tautology does work in the other direction, i.e., all spent fuel is HLW. The main concern in the management of spent fuel is that it must be isolated from the biosphere for a time frame of several centuries. Public acceptance of waste disposal methods is a factor necessary for the success of a new generation nuclear initiative. The lack of public confidence in nuclear waste disposal techniques remains an obstacle in the face of nuclear power. Studies show that all the operating nuclear plants in the world produce some 3,000 cubic meters of waste annually, compared with approximately 50,000,000 cubic meters of solid toxic waste generated by all of U.S. industry.[17] Yet the majority of the public seems less concerned about the volume of nuclear waste and more concerned about the associated risk. The "not in my backyard" mentality with regard to waste disposal facilities has been a perceived obstacle for the advancement of nuclear power for decades.

Reactor Safety

The safety of nuclear power plant reactors is definitely a matter of public concern, which is understandable for a technology whose introduction took place in the form of an atomic bomb. For example, in 1976 it was stated that one 1065-megawatt reactor at the Peach Bottom reactor site in Pennsylvania would produce as much radioactivity in an operating year as the fallout of 1000 Hiroshima-sized atom bombs.[18] However, it is impossible for a conventional nuclear power plant to explode like a nuclear weapon.[19] Therefore, nuclear plants do not present a hazard to the public in this respect. Even so, the danger associated with nuclear plants is often intensified when persons who are highly respected by the public testify to the possible risk associated with reactors. For example, Dr. Henry W. Kendall from MIT in Cambridge, one of the leading critics of nuclear power in the United States, alleged that persons hundreds of miles

from fission-power reactors could suffer radiation sickness, genetic damage, and even cancer if five to ten percent of the radioactivity in a reactor were released.[20] It is this type of statement that has caused the general public to constantly re-evaluate nuclear reactor safety.

Even though the nuclear power industry in the United States has held itself to an outstanding public safety record, plant safety is a different issue in terms of financial impacts on the utility. The largest impediment to any public confidence in the nuclear industry that remained in the late 1970's was severely diminished by the largest nuclear reactor accident in United States history—the accident at Three Mile Island. As a result of equipment malfunctions and operator errors, a partial meltdown of the reactor core occurred. Although there were no civilian deaths or injuries, the reactor was a total loss.[21] The entire reactor was not ruined, but the vessel was damaged and the reactor core and internals were destroyed.

The accident in 1979 at Three Mile Island marks a point in time when anti-nuclear articles, books, and advertisements began to thrive. Some of these materials could be labeled propaganda, but regardless of the basis for such ideas, this feeling of dissent toward nuclear power could not simply be discounted. This is because such literature often reflected the true feelings of the public. Accidents Will Happen: The Case Against Nuclear Power by the Environmental Action Foundation features a number of cartoons chastising the nuclear power industry. One cartoon in particular was drawn in the aftermath of the Three Mile Island incident and depicted a blind dog with a walking stick and a collar tag featuring the acronym for the Nuclear Regulatory Commission. This blind dog is leading a blind Uncle Sam.[22] This idea of "the blind leading the blind" definitely did not help to increase public confidence in the safety standards and practices governing the nuclear power industry.

The Nuclear Regulatory Commission (NRC) is the government agency chartered to regulate the nuclear power industry. The NRC is an independent agency established by the United States Congress under the Energy Reorganization Act of 1974. Its mission is to ensure adequate protection of the public health and safety, the common defense and security, and the environment in the use of nuclear materials in the United States. The NRC has held a significant role in building public confidence in the nuclear industry, especially since the accident at Three Mile Island. The public needs to feel confident that the nuclear industry is regulated by an agency that has the public good in mind. For this reason, the perception of the NRC as a competent regulatory entity is essential. The previously mentioned cartoon portraying the NRC as a blind guard dog presents one conception of this regulatory agency. Another perception common to many anti-nuclear units shows the NRC as an arm of the nuclear industry. Many believe that the NRC does not remain objective due to its interest to see the nuclear industry in the United States flourish. One way to increase public confidence in the nuclear industry is for the NRC to depict itself as a neutral agency that can assure public safety where nuclear technology is concerned.

While the NRC has an effect on public confidence in the nuclear industry in domestic sense, the global nature of nuclear reactor safety is also a public confidence issue. An accident originating from anywhere in the world will affect public acceptance of the nuclear industry here in the United States. For example the accident at the Chernobyl reactor in the Ukraine was at least partly responsible in some people's minds for the shutdown of the Hanford N-Reactor. Even though the Hanford N-Reactor as a light-water-cooled, graphite-moderated design had important differences compared to Chernobyl's design, there were enough similarities to raise concerns about the reactor in the U.S. For this reason, the NRC remains cognizant of events in

other countries. To further this effort, the NRC participates in international cooperative projects with other countries bilaterally, multilaterally, and through organizations such as the International Atomic Energy Agency (IAEA). This is a very important role in addition to domestic regulation because a major accident in France, Japan, or other places that use reactors similar to those in the U.S. could conceivably kill any chance of a nuclear power renaissance in this country.

Economics

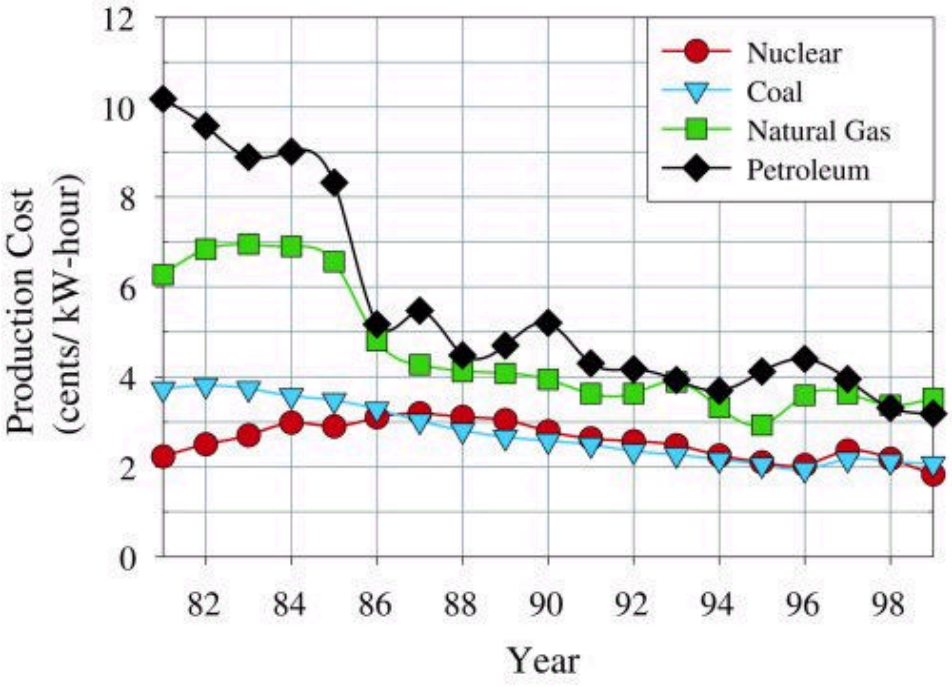
Alongside the safety of reactors, economic factors of nuclear plants play an important role in public acceptance of the nuclear industry. Senator Pete Domenici once remarked, "Reliable, affordable electricity is America's lifeblood. Without it we have no future in terms of prosperity, growth, and jobs."[23] This quote is a direct reflection of the effect economics has on the nuclear power industry and the market for electricity in general. Reliable, affordable, prosperity, growth, jobs—these are the traits and outputs of the American dream. The Generation IV Initiative bears the weight of associating these characteristics with nuclear generated electricity production in the minds of the American public. In addition to the current competitive levels of nuclear power, the Generation IV Initiative calls for economic goals that focus on competitive life cycle cost and financial risk.[24] Beginning in 1999, U.S. nuclear power regained its position as the lowest cost energy production method (see Figure 1).[25] However, production cost expressed in cents per kilowatt-hour is a metric used by economists, investment bankers, etc. to value nuclear power plant assets and investments. The public needs a simpler, more easily recognizable metric. John Ritch, secretary general of the Uranium Institute, emphasized the unit capacity factor as the leading index of improvement for the economic strides of the

nuclear industry.[26] The unit capacity factor is the percentage of maximum electricity a plant can supply to the electric grid, limited only by factors within the control of plant managers.[27] Mathematically, the unit capacity factor is defined as the kilowatt-hours actually supplied in a year divided by the plant's kilowatt rating times the number of hours in a year. Since nuclear plants are base-loaded most of the time, a plant operating steadily above its rating can achieve a capacity factor greater than 100%. The nuclear industry's average capacity factor for 2000 was 91.1 percent, the highest since the Institute of Nuclear Power Operations (INPO) began collecting data (see Figure 2).[28] The proof is there for the public to see that the performance of the current fleet of reactors is aimed at achieving world-class efficiency. The capacity factor is definitely an important feature of plant economics, especially since in most cases the operating plants of today are already paid for. Nuclear power plants for the most part enjoy fixed costs for production. While the capacity factor at a specific plant is increased and production costs remain fixed, nuclear plants enjoy heightened prosperity throughout the period of operation.

Capacity factor is one of several key factors that will influence the construction of new plants. New plants are going to have to meet challenging capital cost goals in order to be economic, even if they run at very high capacity factors. Historically, the cost of construction for nuclear plants has been driven up due to stringent regulations and other requirements.[29] The Generation IV Initiative is working toward a system of standardized reactor designs that could help to alleviate elevated capital costs by balancing safety system requirements relative to potential risk. This equilibrium is necessary in order to avoid regulatory overkill and make nuclear power economically viable. Another factor in nuclear plant economics in contrast to other baseload generation sources is that all of its costs—including insurance, decommissioning, and waste management—are incorporated in the price of nuclear electricity.[30] Incorporated cost

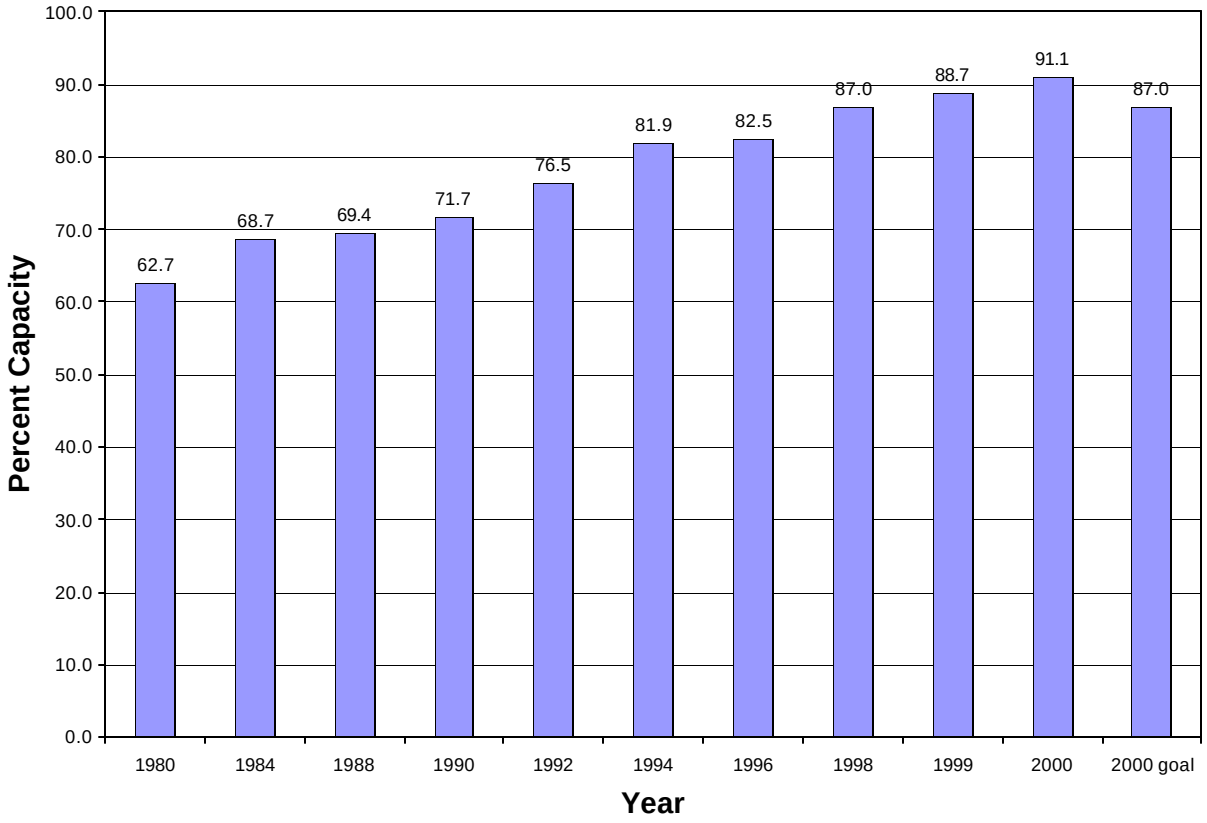
is not necessarily a factor in nuclear power's favor unless the public becomes concerned about the hidden societal costs of other forms of power generation, which does not seem to be the case at this time.

Figure 1. Electricity Production Costs



Source: *Nuclear Energy Insight* Feb. 2001 and NEI

Figure 2. Unit Capacity Factor Growth



Proliferation

Nuclear proliferation often appears at the bottom of the general public's list of concerns over nuclear power usually because members of the general public tend to not understand the concept of proliferation. Nuclear proliferation is the concern that more nations will acquire nuclear weapons capability. Although the public in general has not made nuclear proliferation a number one concern, there is one public interest group, the Nuclear Control Institute, that has made proliferation a priority. The Nuclear Control Institute focuses on nuclear proliferation in a context that is usually not power reactor related but more connected to research reactors since they can more easily be used to create weapons-useable material. Alan E. Waltar, former president of the American Nuclear Society and head of the Department of Nuclear Engineering

at Texas A&M University, suggests that the "linkage between nuclear energy and nuclear bombs is nowhere near as tight as some would like us to believe."[31] However, the stringency of the connection between nuclear power and nuclear weapons is rarely the issue at hand as far as public confidence is concerned. The fact that some semblance of the substance used to construct nuclear weapons can be found in the realm of the nuclear power plant down the road is enough to invoke public opposition to nuclear power in many cases. Dr. Waltar goes on to relate this connection to the link between the fire in the backyard barbecue and the fires that have raged through San Francisco, Chicago, and Yellowstone Park.[32] This analogy suggests that the common perception of a danger is closely related to the level at which the danger is controlled. According to Dr. Robert Dupont, a psychiatrist and expert on fears and phobias who has studied and analyzed social perceptions of nuclear energy, the problem people have with nuclear material is that it is a risk that they do not control.[33] Dr. Dupont goes on to say that people can accept tremendous risk if they control it. However, if someone else controls that risk, people simply cannot allow it. Another issue plaguing public confidence regarding technical and complex issues such as nuclear proliferation was once touched on by Hazel O'Leary, former Secretary of Energy during Clinton's first term and now a private businesswoman, consultant, and attorney. Ms. O'Leary suggests that the degree of confidence built by the public stems from a knowledge base.[34] She asserts that the nuclear industry either talked down to the public in an insulting fashion or, worse, used an influx of acronyms and technical jargon that did nothing but confuse the public more. Lack of control and lack of knowledge concerning nuclear materials are the driving forces behind public concern about proliferation and dangers of radiation in general.

Current Programs, Legislation, and Initiatives

Congress has a clear role in creating a positive atmosphere of public confidence in the nuclear industry through the passage of legislation. The creation of legislation and the initiation of programs that enhance public confidence in the nuclear industry are essential in advancing nuclear technology and introducing new reactors that will aid the United States in its struggle to become an environmental, economic, and energy efficient nation. Several bills and programs are taking on that role today. These initiatives are actively trying to ensure that the nuclear industry maintains a well-trained workforce, continues to operate safely, and has incentive to continue supplying nuclear power.

Pending Legislation

The Nuclear Energy Electricity Supply Assurance Act of 2001 (H.R. 1679 and its Senate counterpart S.472) is one bill currently making its way through Congress that has many objectives intended to support the nuclear industry.[35] This bill has the potential to make an impact on current public opinion toward the nuclear industry by addressing such issues as: the evaluation of opportunities for completion of partially constructed nuclear plants, the assessment of opportunities for Generation IV reactors, and the establishment of the Office of Spent Nuclear Fuel Research to execute a program pertaining to the disposal of high-level nuclear waste. This bill even "declares electricity generated by a nuclear plant to be an environmentally preferable product." H.R. 1679 supports this claim by calling for federal funding to support electricity production facilities that utilize nuclear fuel for emission-free production facility projects.

The Department of Energy University Nuclear Science and Engineering Act (H.R. 2126 and its Senate counterpart S. 242) is another bill progressing through Congress that presents an opportunity to further the effort to increase public confidence in the nuclear industry.[36] This bill directs the Secretary of Energy to endorse a program to sustain the United State's human resource investment and groundwork in nuclear sciences and engineering. If passed, H.R. 2126 will provide funding for student fellowships at Department of Energy (DOE) nuclear science laboratories and promote further interactions between the DOE and universities across the country. An investment in nuclear science education at the collegiate level is perhaps the most beneficial investment that can be made to ensure the advancement of the nuclear industry. If passed, this investment could not come at a better time. Both the numbers of operating university reactors and undergraduate student enrollment have decreased almost consistently since 1980 (see Figure 3).

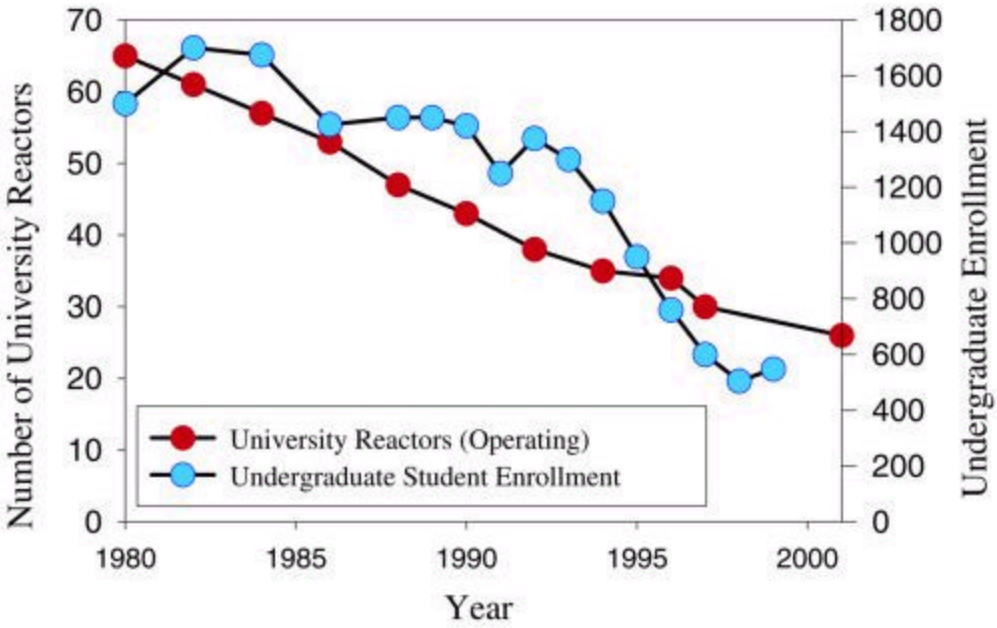


Figure 3. University Trends

Source: Office of Nuclear Energy, Science, and Technology[37]

Education Programs

To supplement legislation encouraging the advancement of nuclear technology through research funding and monetary support for university education, other programs have surfaced recently that offer more fundamental backing to increase public confidence in the nuclear industry. These programs tend to stem from professional societies and additional private organizations. One such program arose from the Nuclear Engineering Education for the Disadvantaged (NEED) Committee of the American Nuclear Society. NEED is currently offering a program specifically designed to introduce minorities and women into the fields of nuclear science. NEED offers teachers, professors, and administrators the chance to write grant applications demonstrating the need for assistance for equipment, funding for field trips, and other items that would enhance classroom teaching in science classes. Mary L. Minor is a teacher of third through eighth graders at Saint Benedict the Moor Catholic School in Washington, D.C., who received one of these NEED grants for supplies in her science classes. Ms. Minor attests that the materials and curriculum planning provided to her by NEED drastically increased her confidence in teaching in the field of nuclear science. This type of assurance in the teacher can cause substantial growth in students' understanding of nuclear principles. "When the teacher is confident, then the students will benefit," Ms. Minor commented, "[This] organization is the highlight of my teaching career."[38] Ms. Minor also reflects on the self-importance that she can see in her students when they master concepts that are often deemed beyond conception for children their age. She sees a sense of pride and accomplishment in their eyes. This is the gaze where the future of the nuclear industry is held.

Industry Programs

Most sources agree that the public confidence environment is the most positive in the vicinity of nuclear power facilities. In fact, Mr. Edward Conaway, public affairs administrator for the South Texas Project Nuclear Operating Company (STP), says that public confidence in the STP facility is not an issue locally due to the extent that the plant has become involved in the community.[39] In Wadsworth, Texas, the South Texas Project is the largest employer and the largest charitable donor. The facility actively contributes to the Women's Center, March of Dimes, and United Way. Employees of STP serve on local councils and commissions, and the company has actively helped to mitigate consequences of electricity deregulation. According to Conaway, the plant is "*the* place for kids to work" on summer breaks. Areas near nuclear plant sites have a positive perception of nuclear power because they see the benefits of the facility on a day to day basis. To them, the plant is a business that brings jobs to their community.

Many people who live or attend school in areas surrounding nuclear plants also have the opportunity to visit and tour the plant facility. Numerous nuclear plants have visitor centers that welcome the public to come in and learn more about nuclear technology and its place in society. Globally, nuclear plant visitor centers take on two objectives: to make the site and facility known and to provide information on nuclear issues.[40] Visitor centers are particularly effective in France and Japan. The majority of these centers do not strive to have the site accepted or to promote nuclear energy. Instead, visitor centers see their task as essentially to inform the public rather than to serve an advocacy role. This type of program is an excellent way to increase public confidence in the industry by making the average person feel more comfortable with the facility and the plant operations. This goes back to the idea that people fear what they cannot control and what they do not understand. If a person feels at ease inside the plant in very close

proximity to the reactor itself, then chances are that much of the unnecessary fear this person has associated with nuclear power will disappear. Dr. Robert Dupont has related this type of scenario to a situation involving a person who is afraid of flying in an airplane.[41] To help this person deal with his fear, Dr. Dupont first wants to get him on an airplane. He does not ask the person to sit and listen to an extensive lecture concerning the fundamentals of propulsion and thrust that cause an airplane to leave the ground. He makes every effort to humanize the scary environment. Therefore, Dr. Dupont takes his fearful flyer onto an airplane. He has the person talk to people, meet the pilot, and tell the flight attendants that he is a fearful flyer. This is exactly what visitor centers do with nuclear power. The objective is not to isolate people from the nuclear industry. Instead, the effective way to coax public confidence toward the side of nuclear power is to take people to the plants, have them talk directly to the engineers, and let them see the control room first-hand.

Recommendations

A background has now been established regarding the issues associated with nuclear power that most concern the public as well as a few of the legislation, programs, and initiatives that are in place to address those issues. The United States has undeniably progressed but still has a long way to go in the effort to establish firm public confidence in nuclear technology. Richard Stallings, former U.S. Nuclear Waste Negotiator, has his own suggestions of how to improve public confidence in the nuclear power industry. He suggests shutting down 20% of the power in U.S. cities and asking people to spend a week as if there was no nuclear power in the United States.[42] Even though this seems humorous and completely impractical, the time is definitely right to actively pursue this goal of conveying to the public the necessity of nuclear power as the Department of Energy persists toward the development of next-generation nuclear reactors. The Generation IV Reactor Initiative presents an opportunity for a renewed image of nuclear power as an up-to-date, dynamic, beneficial industry. The following list of actions will provide the beginning of a more proactive effort to increase public confidence in the Generation IV Initiative in order to meet future energy and environmental goals in the United States.

Legislation

The Nuclear Energy Electricity Supply Assurance Act of 2001 and the Department of Energy University Nuclear Science and Engineering Act should be passed through Congress in order to jump-start funding to support the nuclear industry in the upcoming fiscal year. Funding for an evaluation of opportunities to complete partially constructed nuclear plants and further

assessment of opportunities for Generation IV reactors is necessary in order to increase public confidence in reactor safety.

Establishment of the Office of Spent Nuclear Fuel Research (OSNER) would serve to address the public concerns pertaining to the disposal of high-level nuclear waste. With the issue of waste disposal at the top of the list of public concern, the OSNER should address this issue in a manner in which the general public can comprehend. This may merit the need for public education regarding the characteristics of nuclear waste as well as the features required to create a waste repository and information on the level of safety that such a repository would maintain.

The advancement of public confidence in the ability to safely and economically use nuclear energy also depends on exceptional human performance. The current workforce in the nuclear industry is aging. Programs endorsed by the bill that encourage partnerships between university nuclear programs and the Department of Energy will definitely serve to maintain this firm foundation of workers in nuclear science.

Education

In order for public confidence in the nuclear industry to rise in the United States, a solid education in principles of radiation for the general public is needed to supplement university curriculum. The June 2000 report of the Nuclear Energy Research Advisory Committee (NERAC) Subcommittee on Long-Term Planning for Nuclear Energy Research emphasized that the U.S. must maintain a strong commitment to the education and training of nuclear engineers and scientists because of the broad application of nuclear technology across society. These issues include: commercial nuclear power, radioisotopes for nuclear medicine, and radioactive waste management.[43] However, the federal government pays little attention to the sort of

education program as has been administered by the American Nuclear Society's Nuclear Engineering Education for the Disadvantaged (NEED) program. This responsibility of public education is often left to professional societies and industry because government agencies do not want to be perceived as taking an advocacy position. When one thinks of government education on nuclear power, flashbacks of Eisenhower's Atoms for Peace program come to mind. Many considered this program to be propaganda, and others even saw it as a government ploy to promote nuclear power. It is time for the United States to deploy a comprehensive radiation education program in schools across the nation. This education program should cover such topics as the fundamentals of radiation as well as health effects and the relative risk associated with various levels of radiation exposure. The American public as a whole simply is not sufficiently educated on the fundamental concepts of radiation. As has been iterated in previous sections, public confidence is partially dependent on the familiarity of concepts involved. This type of public education program would serve to greatly increase the knowledge base of the American people concerning the widespread uses of radiation in society, including the use of fission to generate nuclear power. Several organizations such as the Nuclear Energy Institute, Department of Energy, and the Health Physics Society have educational materials, but collective efforts to make these materials available to the public are not in place.

Public/Industry Interaction

Another tool for public education is the power plant facility itself. These facilities are already in existence throughout the country and would not require any initial program development or planning in order to utilize them for the public. Along with the deployment of the Generation IV Initiative, the nuclear power plants in the U.S. should be ready to release an

"ad campaign" of sorts to rally around the picture of a new and improved nuclear power industry. Nuclear power needs the positive publicity that would be afforded to any up-and-coming product on the market. More people should be made aware that plant facilities are open to the public for tours.

A common misconception is that nuclear energy does not merit an ad campaign because it is a generic commodity with no "brand name" attached. However, the nuclear power industry can benefit from advertising just as eggs, milk, beef, and pork have. "Pork—the other white meat," "The incredible, edible egg", and "Got milk?" are all well known slogans for generic commodities. However, "Nuclear, the clean air energy" is a catch phrase that is only thrown around at conferences put on by the Nuclear Energy Institute where only those who are already quite familiar with nuclear power attend. Nuclear power simply is not brought to the forefront of public thought. Instead, it is isolated from public sight as plants are built in rural areas. This fact can and should change as the Generation IV Initiative is introduced to the public. Generation IV is an opportunity for nuclear power to make a comeback, but in order for the industry to stay alive there must be new construction of plants before 2030.

Research and Development

Continued research and development is also imperative in order to achieve a heightened state of public confidence in America's nuclear power industry. The waste disposal issue has already been identified as a chief concern of the public. Therefore, the Department of Energy should continue any additional research and/or development necessary to create a storage facility for HLW in order to prove to the public that radioactive waste is manageable.

Another issue worthy of research and development funding is the economic viability of nuclear plants. Greg Reuger, Chief Nuclear Officer, Pacific Gas and Electric, and Chairman, EPRI Nuclear Power Council commented to the Nuclear Energy Research Advisory Committee concerning the issue of high capital costs for new plants. He said, "New reactor designs that cannot demonstrate their ability to compete financially in the marketplace will not be built, pure and simple."[44] If one goal of the Generation IV Initiative is to deploy new reactors by 2030, there must be active research and development efforts to improve the capital cost factor of new plant construction. In order for confidence in the nuclear power industry to increase, the public needs to see a new reactor built in a timely fashion, and they need to view the reactor providing benefits to their community and environment. New plants must be economically viable in order for utilities to risk capital and public good will when licensing and constructing new facilities.

Conclusions

Public confidence in the nuclear industry is a factor that cannot be taken lightly. There are people who declare that public opinion toward nuclear power has been permanently scarred beyond repair because of accidents such as the partial core meltdown of Three Mile Island Unit Two in 1979. Others proclaim that public confidence has no effect on the industry, and although it is swayed by the events of the times, the fate of the industry is affected primarily by the regulations that govern it. However, the conclusion of this report is that heightened public confidence is necessary for the Generation IV Reactor Initiative to be successful. Generation IV presents a unique opportunity for various parties such as the Department of Energy, professional societies, and nuclear power facilities to step up to the challenge of meeting public opposition head-on.

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